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The impact of oil price on food security in the Algeria, Iran, and Saudi Arabia: cointegration, vector-error correction model, dynamics, and causality analysis

Ahmad Yazdanpanah
Iowa State University

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Yazdanpanah, Ahmad, Ph.D.

Iowa State University, 1994

U·M·I
300 N. Zeeb Rd.
Ann Arbor, MI 48106

The impact of oil price on food security in the Algeria, Iran, and Saudi Arabia: Cointegration, vector-error correction model, dynamics, and causality analysis

by

Ahmad Yazdanpanah

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"He who has knowledge but no acts is like a bee without honey".

Saadi
13th century Iranian poet

This work is dedicated to the memory of my late mother, who often sacrificed her food to feed us, and was my first teacher in economics with her act.

To my motherland, Iran, may this piece of work contribute in its sufficient availability and affordable accessibility of food to all people. that someday no one will have to sacrifice their share in order to feed her people.

TABLE OF CONTENTS

CHAPTER I. INTRODUCTION

Importance of the Study

The Middle East and North Africa (MENA) comprise 20 countries, most of which do not possess the agronomic capacity or environment to efficiently produce enough food to meet the demand generated by population and income growth (Kurtzig et al., 1988). As a result, the region in general and oil exporting countries in particular are heavily dependent on food imports. In 1992, MENA agricultural imports were estimated at $29 billion (about 10% of global agricultural imports). The ability to import sufficient food to meet domestic requirements is largely a function of the economic development level and export earnings. On the one hand, the oil-rich economy of Saudi Arabia allows financing of food import needs from export earnings, while Egypt on the other hand, heavily dependent on food import subsidies, is primarily financed by external borrowing.

The region's agricultural imports increased dramatically in the 1970s, commensurate with higher oil price and export earnings, but slowed as income gains weakened in the early 1980s. Due to increasing oil prices and a continuing population growth rate of 3 percent per year, agricultural imports recovered in the late 1980s.

During the last 20 years food imports have become critical to the food security programs of MENA countries. With the exceptions of Turkey, Morocco, and Iran, all countries in the region import at least half their food supply. In 1990, the cereal self-sufficiency rate (domestic production's share of total supply) of the major MENA food importers ranged from 22 percent in Algeria to 99 percent in Turkey.

For all oil exporting countries, oil export earnings are the primary engine of economic growth and the major source of foreign exchange earnings to finance food imports. The share of oil, as a percent of total exports, ranges from well over 90% in Iraq, Oman, and Saudi Arabia, to over 65% in Iran, Egypt, Kuwait, the United Arab Emirates and Libya in the 1986-88 period. Even in Algeria where natural gas is a major export commodity, the share of oil in total exports was 46% in the same period. The region's countries hold nearly 70 percent of the world oil reserves and over 30 percent of its natural gas reserves. The middle East exports over 70% of its oil output, while North Africa exports about 60%.

Given the limitation in agricultural resources and unfavorable climate, food security strategies are at the forefront of national development plans in the region. A typical policy goal is the provision of an uninterrupted supply of cheap foodstuff "for all people in all time" particularly the low-income sector of the population. The availability of a cheap and steady food supply largely depends on oil prices. However, oil prices have a high variation in the short run; hence, oil is not necessarily a reliable source for development and food import financing. Furthermore, since oil is a non-renewable resource, it can not be depended for sustained food supply in the long-run. For example, the uncertainty ranges for oil prices based on oil price of 1990 are projected to be 16.00-25.30, 17.90-31.80, and 22.60-40.20 in 1995, 2000, and 2010, respectively (the actual price in 1991 was $18.40 per barrel) (Fried and Trezise, 1991). As a result, both agricultural production and agricultural trade (imports as a means for food security goals and agricultural exports as a means for diversification goals in a oil based economy) are characterized by extensive government intervention aimed at domestic self-sufficiency in staple foods (wheat) in the region.

The MENA countries offer a very rich subject to investigate food security issues. Due to their lack of comparative advantage in food production and substantial export earnings from oil, MENA countries have wider options in meeting their food requirements and food security (e.g., through imports) than other developing countries. On the other hand, because of their socio-political situation (e.g., threat of food embargo) food security considerations rank high on their agricultural policy agendas. Finally, the prominence of oil export revenues in its economies gives a strong link of food policy (e.g., food security) to the macroeconomy and to the economy of the rest of the world. This study builds on some earlier studies and capitalizes on this rich mix of dynamic interaction among variables impacting food security with the end view of uncovering useful insights for improving policy formulas.

Objectives of the Study

The general objective of this study is to better understand the food security issues in an oil-exporting developing country setting, with the ultimate purpose of improving food policy making and planning general food policy directions and policy initiatives in response to the food security issue. Three countries belonging to the Middle East and North Africa (MENA), and the Organization of Oil Exporting Countries (OPEC), namely, Algeria, Iran, and Saudi Arabia, are examined to provide some variation in policy response to food security issues.

Specifically, this study aims to (a) examine the presence or absence of any substantial relationship, in either causal direction, between relevant macro variables such as oil price, domestic food production, and food imports and their relationship with food consumption using the Granger-Causality test, (b) determine the magnitude (whether large or small), direction (whether direct or inverse), persistence (whether short-lived or long-lived), and permanence (whether transitory or permanent) of a shock in each of the relevant variables influencing food security by introducing a one-period shock and tracing through its effects after accounting for the simultaneous and cumulative lag adjustment through an impulse response analysis; (c) measure the relative importance of each relevant variable in explaining the variability of consumption including their lag structures using variance decomposition analysis; (d) review the food policy initiatives of the three countries and their food security ramifications; and (e) derive policy implication for food policy relating to food security.

Organization of the Dissertation

Chapter II summarizes the main points of the conceptual framework for food security analysis and the relationship of food self-sufficiency and oil prices with food security. Chapter III provides an overview of natural resources and the climate situation in Algeria, Iran, and Saudi Arabia and traces their respective agricultural development and policy initiatives. Chapter IV summarizes the causality concept and techniques used for testing and proper treatment of the time series properties of data including the use of a VAR model in exploring the dynamic relationships among food security variables. Chapter V applies a causality test specifically for Iran. Finally, Chapter VI offers a summary and conclusions.

CHAPTER II. FOOD SECURITY: AN OVERVIEW

As more developing countries recognize the advantages of a dynamic agricultural sector, increasing focus is given to food policy. Among others, four objectives are commonly pursued: (1) efficient growth in the food and agricultural sector, (2) improved income distribution, primarily from the extension of employment, (3) adequate food and nutrition for the entire population through provision of a minimum subsistence floor, and (4) food security to insure against bad harvest, natural disasters, or uncertain world food supplies and prices (Parker, 1989). Food security policies are extremely important to a developing country because they affect (a) nutritional adequacy, (b) farm income, (c) food prices and political stability, (d) agricultural productivity and the potential for industrialization, and (e) the government budget and foreign exchange reserves (Ender, 1983). Moreover, as Maxwell (1989) emphasized, better understanding of food security issues is the single greatest priority in improving food policy making and planning in developing countries. This is the task of this chapter. The evolution of the food security concept is reviewed and some definitions related to food security are offered from different approaches and different units of analysis.

Food Security: A Conceptual Framework and Preview

During the past three decades, the focus of food security research has evolved from an examination of concepts such as nutrition, food production, and price policies to an examination of household (micro-level) and national-level (macro-level) food security systems and mechanisms. The literature in this area is extensive, including, among others Gittinger, Leslie, and Hoisington (1987), Hollist and Tullis (1987), Valdes and Konandreas (1981), and Bigman (1982). In the 1960s, research in food security measures focused on expanding agricultural production and supply. The variability in food supplies in the early 1970s resulted in a shift in research emphasis on buffer stocks, balance of payments stabilization, trade polices, and food aid programs (Phillips and Taylor, 1990). As mentioned by Parikh and Tims (1989), tracing the history of the food security concept reveals an interesting process of changes in perceptions regarding the world food problem and food policy.

In fact, the history of food security research shows two distinct waves. The first was stimulated by the world food crisis of 1972-74 which peaked in the early 1980s (Clay, 1981). The second was catalyzed by the African famines of 1984-85 which gathered momentum through the late 1980s (see, for example, World Bank, 1986, FAO, 1989). It started out as a concept primarily defined at the international level with reference to stable world market conditions and stable prices. Logically, it was then extended to the national level as the disturbances in world markets were traced to supply and demand instability both through national causes and as a consequence of national and international agricultural and food policies. Finally, the concept was extended to the individual and household levels and to the objective of securing access for all to adequate amounts of nutrition. For a number of reasons this study takes the national perspective of the food security issue. First, although some variability may originate from external sources such as instability in the international markets, it is at the national level where policy decision are made to accommodate these external shocks. Also, food security at the household level is largely influenced by national food security policy. Hence, the following discussion pays particular attention to the national food security concept.

The concept of food security

In 1981, at the height of the first wave of interest in food security, Clay (1981) argued that food security is a problem most often conceptualized as a macro phenomena particularly as deviations from the trend in aggregate consumption. The World Bank defines food security as: "Access by all people at all times to enough food for an active and healthy life." Its essential elements are availability of food and ability to acquire it. The European Community (EC) defines food security as "the absence of hunger and malnutrition. "The necessary condition for this to be possible is having enough resources to produce food or otherwise obtain it. This is not sufficient, however, because the resources must also be used well." Maxwell

(1989), proposed a wider concept arguing that: "A country and people are food secure when their food system operates efficiently in such a way as to remove the fear that there will not be enough to eat." Other definitions of food security consider a global unit. For example, Smith (1990) defined it as the availability and affordability of food, mainly grains, to meet consumption needs of people in all countries. On the other hand, food insecurity is the lack of access to enough food. There are two kinds of food insecurity: chronic and transitory. Chronic food insecurity is a continuously inadequate diet caused by the inability to acquire food, and transitory food insecurity is a temporary decline in household's access to enough food (World Bank, 1986).

The concept of food security can also be considered in long-run and short-run horizons. In the long-run, food security depends on a country's economy to generate and distribute purchasing power sufficient to adequately feed all its citizens, from domestic production or imports as supplement of domestic production. On the other hand, food security in the short-run is concerned with how nations, either individually or collectively, cope with inadequate availability of or access to food (Smith, 1990). The lack of food security may result from transient shocks that threaten the supply or distribution of food. Such shocks may originate within a country from such causes as drought, floods and others, which can be categorized under "acts of God." For a country heavily dependent on food imports, the shocks may also originate from outside, mainly as "acts of man", like when prices of imported food rise sharply because of changes in policy or labor strikes in major food exporting or importing countries. The shocks themselves may have nothing to do directly with food, but may compete for scarce foreign exchange in a country's import budget (Kennedy and Nightingale, 1989).

Different approaches to food security concepts may have three common themes. First, they focus on access to food rather than simply on supply. Food security is therefore, concerned not just with the level and variability of food production but also with causes and dimensions of lack of "entitlement" and with the effectiveness of the distribution system. The second theme pays more attention to variability as well as to trends, that is, variability in food production, food prices, food imports or ability to acquire food. The third theme, is the broad mandate of food security, implicit in most definitions, encompassing production, marketing and consumption issues and ranging across levels of analysis from the household to the national and international economy (Maxwell, 1990).

Review of Previous Studies: Causes and Effects

Causes and solutions of food insecurity have been and will continue to be an important research issue. Most studies treat only a sub-sector (production), not the whole economy, and mostly focus on the micro level, that is household access problems, not aggregate supply (domestic production and imports). The study of food security from methodological consideration can be divided into two groups:

(a) causes of food insecurity and (b) effects of food insecurity. The researches on the causes are based on analysis of variation in food consumption, measured by using coefficient of variation (cv), and the probability of consumption falling below trend at a specific level of significance (say, 95%). Examples of this type include Green and Kirkpatrick (1982), Valdes and Konandreas (1981), and most recent by Adamowicz (1988) and Sahn and Braun (1989).

Green and Kirkpatrick examined a food balance sheet equation (due to lack or limitation of data on changes in stock and/or waste, most studies use an incomplete equation : $C = Q + F - S$

where C= Consumption, Q= Production, F= Imports, S=Export (goods and services).

The variance of consumption can be written into the variance of its components:

$$\sigma^2{}_{CC} = \sigma^2{}_{QQ} + \sigma^2{}_{FF} - \sigma^2{}_{SS} + 2\,\sigma_{QF} - 2\,\sigma_{QS} - 2\,\sigma_{FS} \qquad (2.1)$$

To measure the sources of food insecurity, they use regression analysis to test the explanatory power of respective components, say the relative contribution of the variance in imports in explaining the variance in consumption. They found that the variation of production has the largest effect on variation of food consumption and, in turn, in food insecurity. Valdes and Konandreas examined the variability of food supply in developing countries for 1961-76 as a function of food import bill, that is

$$V = M P \tag{2.2}$$

where

V = value of food imports

M = imports of food in quantity terms

P = price of food

Expanding the above identity, taking expectation and expressing in variance we get

$$Var(V) = P^2 var(M) + M^2 var(P) + 2PMcov(P, M) \tag{2.3}$$

Furthermore, (2.3) can be further simplified as:

$$R_m + R_p + R_{mp} = \frac{P^2 var(M) + M^2 var(P) + 2PMcov(P, M)}{P^2 var(M) + M^2 var(P)} \tag{2.4}$$

R_m = variation due to quantity

R_p = variation due to price

R_{mp}= variation due to interaction

They indicated three main causes of food insecurity: (1) shortfall from domestic production, (2) sudden increase in world prices for food imports, and (3) decrease in prices of exports (goods and services) that are used for payment of import bill. They focused on food imports as the most important source. They found the variability in the quantity of imports as the major source or cause of import bill variability. They used coefficient of variation (cv) to compare variation in consumption among countries (including Algeria) included in their study. Adamowicz studied grains production and food security in Arab countries based on food security as a problem of short-term variability of food production and instability of imports. He measured food security by the size of production and consumption variability in relation to the long-term level of consumption and production, and followed Valdes' method by using the standard deviation and coefficient of variation (cv) as indicators of variability. He focused on variation of domestic production as basic source of food insecurity in Arab countries.

Based on Adamowicz's study, Saudi Arabia and Algeria, for example, had a high instability of food production in per capita terms, 21.5 % and 11.6 % respectively. For Saudi Arabia this instability originated from an upward trend in production, but for Algeria it was the adverse effect of weather and other variables. The CV of grains production in Saudi Arabia and Algeria for the period 1973 to 1984, were 76.2 and 24.0 percent, suggesting that Algeria may have a higher demand for imports of grain in that period.

Sahn and Braun examined FAO food balance sheet data for 16 developing countries (including Iran). Using a methodology similar to that of earlier studies, they found that the level of variability in cereal production is generally greater than consumption variability (nearly twice) during the period 1966-80. They also found that whether through trade policies, domestic stock behavior or other actions affecting supply, the aggregate level of variability in production is not fully transmitted into consumption variability. These studies, searching for the source of consumption variation, differ in the unit of data--in per capita terms or total terms, time period covered, set of countries examined and sources of data.

One of the most recent studies on the causes of food insecurity in less developed countries was done by Diakosavvas (1989). This study investigated factors affecting food consumption by using correlation between two ''external'' factors(such as value of food imports and real merchandise exports) and two ''internal'' ones (such as real per capita income and domestic food production). Based on cross-sectional analysis, he found that instability in domestic food production is the most important single factor accounting for food consumption instability.

Some researchers use probability of shortfall in analyzing the causes of food insecurity. For example, Bachman and Paulino (1979) tested the linkage between population growth and trends in production and the probability of food insecurity for developing countries. They found that countries with more rapidly increasing incomes and/or lower growth in population are more likely to be self-sufficient in food.

Analysis on the effects of food insecurity

Anderson and Scandizzo (1984) defined food insecurity in terms of probability of starvation. Using a cross-sectional data set on developing countries, they tested the relationships expressing food risk as a function of normal food availability, distribution risk, and production risk. Among other things, they found variation in production and purchasing power as major factors having negative effect on people's welfare.

The Macro-economy Environment and Food Security

The macro-economy plays a major role in determining food security at all levels, through its impact on production (the effect of incentives), availability (the effect of trade and food security arrangements), and access (the effect of the capacity to import through export earnings and capital flow, and the effect of employment and income generation). These impacts, in turn, are determined mainly by national macro-policies which governments control (internal macro-economy), and through parameters imposed by international environment (external macro-economy)(Alamgir and Arora, 1991). The main issues to be considered at the macro-level (national level) concerning assessment of food security include the aggregate levels of food production, agricultural and non-agricultural production for export, recent evolution and projection of these levels, and developments in terms of trade and variability in production and trade levels.

Since this dissertation is about the impacts of fluctuation in oil prices on some oil-exporting developing countries, we first listed factors affecting the food security of a specific country. Then, since all countries under study pursued self-sufficiency in food policy, the relation of self-sufficiency to food security and impact of oil price shocks on agriculture sector are considered in the next section.

Factors affecting the food security of a specific country

Based on Smith (1990), important demand-side factors affecting food security include: (a) population growth, (b) income growth and distribution (related to internal fiscal and monetary policies, world economy environment, distribution of rights and food assistance programs), and (c) export revenues and indebtedness (related to domestic and foreign monetary policies, domestic economic shocks and incentives for import substitution or export promotion). On the supply-side, the important factors which affect food security at the national level include: (a) weather (erratic weather is a major source of variation in domestic production of food), (b) production and production growth rates (depending on applications of technology, such as new crop varieties, tractors and fertilizers, in adequate levels and at appropriate times), (c) policy incentives to produce food for domestic needs (as influenced by world prices, internal pricing policy, adequacy of internal infrastructure to support marketing, such as roads and institutions), (d) stock behavior and (e) availability of imports (food policies of major exporters, foreign constraints and reserves, and dependency level)

Food self-sufficiency and food security

"Food security" is sometimes equated at the national level with "food self-sufficiency". This is not necessarily the meaning adopted in this study. Theoretically, it is possible for a country to be better off by pursuing a trade-oriented policy. That is, according to its comparative advantage, it may pursue domestic production and/or imports to meet domestic food demand. While some studies suggest that there is no necessary link between self-sufficiency and food security (see, for example, Reutlinger and Pellekaan, 1986), these do not prove that resort to imports will enhance food security for all vulnerable groups either. In this respect, food security is a direct function of how the imported food and purchasing power is distributed (Alamgir and Arora, 1991). According to the World Bank (1986), the frequently advocated course of action to increase national food production for self-sufficiency is neither a necessary nor a sufficient condition for reducing chronic food insecurity. An increase in food self-sufficiency which involves the reduction of food imports without having secured an equivalent increase in domestic production is likely to make things worse. More food production is not necessary for improving food security because the domestic food supply can always be increased through greater imports or less exports of food, and existing food supplies can be redistributed.

More food production is never a sufficient condition in the achievement of food security because it does not guarantee that the people who need more food will have the ability to acquire it.

For a large group of developing countries, however, the focus on food security at the national level tends to be bound up with concerns for national food self-sufficiency and dependency. Some developing countries, including oil exporting countries such as Mexico, were concerned that reliance on food imports, most notably grains, from a few exporters would create an undesirable and potentially difficult dependency. The tendency for some food exporters to talk of the "food weapon" as an international political leverage, coupled with the grain embargo against the former Soviet Union in 1980 and later threat of food embargo against some Persian Gulf countries reinforced this anxiety. Political vulnerability aside, most food importing countries, even oil exporting countries, face foreign exchange constraints for food imports. Food security, therefore, became bound up with the idea of increasing national production of basic food, reducing reliance on an unstable international market. The precise structure of national production (and the cost of this kind of policy) is of secondary importance (Corbett,1991).

In addition, the consequences of the policies of major food producers and exporters influence the supply, price and distribution of food in food importing countries. Therefore, their polices play an important role in food security of food importers. In this respect, to reduce the threat to food security of food importing developing countries from major food exporters, prohibition of export restrictions, among others, became an important component of agricultural reform polices, recently receiving high priority in the General Agreement on Tariff and Trade (GATT) negotiations. This would allay the fears of importers that international trading institutions may be unreliable source of supply and negate one argument for food self-sufficiency as the basic of food security (Ballenger and Mabbs-zeno, 1992).

The two other international agencies involved in food, i.e., the World Food Council (WFC) and FAO argue more or less explicitly that national food security is fundamental to food security. For example, FAO believes the emphasis on greater food self-sufficiency, particularly in staples which are regarded as key contributors to food security, stem from important political perceptions as well as economic considerations (FAO, 1985). Despite their lack of comparative advantage in food production, some developing countries (e. g., Middle East oil exporters) followed industrial countries in the 1960s and 1970s in aiming for food self-sufficiency to insulate themselves from the world market (Broun,Golden, 1992).

Some countries or regions of the Third World that used self-sufficiency as an instrument for food security goals showed some success. For example, the self-sufficiency objective coupled with domestic price stability measures have been the only mechanism by which the Southeast Asia region (e.g., Indonesia, the largest importer of rice in the world through most the 1970s, was able to cease importing rice by the mid-1980s) avoided the destructive effects of the international price instability on the domestic agricultural sector development. In this context, food self-sufficiency in much of Southeast Asia represents a national and regional approach to food security and assurance of supply. This food security concern extended not only to assuring adequate national supplies, but also to assurance that food is generally available to all parts of the population to avert chronic pockets of hunger and shortage (Baharsjah et al., 1989).

Oil prices and agriculture sector

The role of macro prices such as the exchange rate and the rural-urban terms of trade (or food prices for short), in influencing the rate and composition of structural change in an economy has been emphasized as a major component of agricultural and food policy (see, Timmer, Falcon, and Pearson, 1983; and World Bank, 1986). In fact, the two oil price shocks in 1973/4 and 1979/80 offer an opportunity to model a major perturbation as it ripples through the macro economy and into the agriculture sector. No other single macro economic event in recent history has so opened windows of opportunity for understanding cause-and-effect relationships between the food and agriculture sector and basic macro prices variables (Timmer,1984). As Schuh (1976) suggests, agriculture tends to produce a relatively large share of tradeable goods and thus oil exporting countries usually face a deterioration of the rural-urban terms of trade when oil prices sharply rise.

In response to a shock from either a resource discovery or increase in price of export oil, if income is spent, the consequences includes a "resource-movement effect", which draws factors of production out of other activities and into the booming sector (oil sector), and a "spending effect", which draws factors of production out of activities producing traded goods (to be substituted by imports) and into non-traded sectors (typically construction and services). The contraction or stagnation of the traded sector (agriculture and industry) is sometimes referred to as the "Dutch Disease" (see, for example, Gelb, 1989). The term Dutch disease was first used in the mid-1970s and referred to the adverse effects on Dutch manufacturing of the Schlochtern natural gas discoveries of the 1960s via their impact on the Dutch real exchange rate (Struthers, 1990). Corden (1982) and Nearvy and van Wijnbergen (1980) are two surveys of the core model of Dutch disease. As some studies have shown, the core model of Dutch disease is inadequate for addressing the impact of oil price fluctuation on traded sectors of oil exporting developing countries. (The World Bank study in 1984 showed the manufacturing sector of oil exporting countries after the oil boom of 1970s actually expanded and agricultural sector contracted in all cases.) The core model has been modified to explain this outcome. The main prediction of the modified Dutch disease theory consist of exchange-rate overvaluation, rapid expansion of the enlarged booming sector, and agricultural stagnation or decline (Majd, 1991). Benjamin, Devarajan and Weiner (1988), Fardmanesh (1990), Struthes (1990), and

Majd (1991) are four of the most recent modified Dutch disease models in the literature.

However, as most researchers of the Dutch disease model suggest, this decline in agricultural production is not inevitable. The experience of Indonesia, for example, suggests that a wide range of policy tools can be used to reduce negative impact of oil price boom in the agricultural sector. Direct price and trade polices can be used to alleviate relative price movements disadvantageous to agricultural producers caused by "Dutch disease". But this policy requires substantial resources and expertise to be successful. The most powerful and flexible policy instruments during an export boom are probably direct government expenditure and investment (Scherr, 1989).

Analysis of the impact of oil price shocks through the Dutch disease model has some shortcomings such as using general equilibrium methods based on the full employment assumption which is not consistent with developing economies of oil exporting countries. According to Richards(1987), in his study about food security in Middle East and North Africa (MENA) region, the inflow of oil wealth was a "very mixed blessing" for oil exporters' agricultural sectors. He argued that the problem of Dutch disease have been over rated since World Bank data indicate that oil exporting middle income countries agriculture sectors grew at 2.8 percent from 1970 and 1982, whereas oil-exporting, middle-income countries agriculture grew at 3 percent (for high-income oil exporting the rate was 5.6 percent). Based on Richards argument the ensuing model of agrarian change in the MENA region had the flowing elements: (1) abundant foreign exchange (due to two oil shocks), (2) outflows of labor from the major agricultural producers, (3) accelerating imports to feed the cities, (4) inputs subsidies and specialty crop promotion for the larger farmers, (5) migration and (some) increased commercialization for small farmers and the landless, (6) food subsidies for the urban population, and (7) some changes in the mode of finance of these subsidies, with general tendency to take funds for general tax revenues, now augmented by oil and aid, rather than to obtain the revenue by shifting the terms of trade against agriculture.

The decline in oil prices following 1983 has put all the above models under considerable pressure mainly because they focus on the Dutch disease theory that developed to explain the effect of oil boom prices on agricultural sector in a oil exporting country. The Dutch disease theory besides its assumptions defect suffers from two main shortcomings. First, at the theoretical level it is fomulated in such a way as to imply that events occur automatically and mechanically; it fails to take account the sociopolitical process involved, particularly the role of government policies. Second, at the empirical level, it fails to explain the diverse experience of the oil-exporting countries after the price rises of 1970s and early 1980s (such as Algeria, Indonesia, and Iran) (Shafaeddin, 1988).

In summary, earlier studies have contributed in establishing the impact of some variables on food consumption. This study extended these analysis to capture the richer mix of interactions of variables impacting food security which might have excaped notice with the major focus on production in earlier studies and their common use of a single point estimate measure of covariability (e.g., the coefficient of variation). Moreoover, the use of cross-section data across countries may hide the more important influence of structural changes in the economy, gestation period of infrastructure invesment, and policy changes whose influence on food security can only be traced over a lengthy period of time.

Chapter IV is devoted to an extended description of the methodology used in this study to highligh its appropriateness in explaining important issues related to food security.

CHAPTER III. AGRICULTURAL POLICY: AN OVERVIEW

Constraints and Agricultural Situation in the Region

The political economy of the Middle East and North Africa (MENA) countries in general, and of Algeria, Iran, and Saudi Arabia in particular are dominated by three important factors: little rain, much oil, and rapidly growing populations. The increase in agriculture production to meet the expanding demand as population (see Table 3.1) and income (see Table 3.2) grow is ultimately a function of climate, soil condition, resources (agricultural land, water supply) availability and technology. The limitation of agricultural resources in all countries under study is discussed in the next section. To complete that picture we consider available data about some of these factors in the world and MENA.

Despite the fact that all three countries have relatively large land areas, in 1989 the share of agricultural land in total land were only 3, 9, and 1 percent in Algeria, Iran, and Saudi Arabia, respectively (see Table 3.3). Table 3.3 indicates also that the growth rates of agricultural land was extremely different among these countries. For example, during the 1965-1989 period, agricultural land in Saudi Arabia increased annually by 1.9 percent, while the growth rate in Iran was negative (-0.4) partly due to high rate of urbanization and increasing demand for

Table 3.1. Population growth and projection

average annual growth of population (percent)			
	1965-80	1980-90	1989-2000
Algeria	3.1	3.0	2.8
Iran	3.1	3.6	3.4
Saudi Arabia	4.6	4.7	3.7

Source: World Development Report, 1992.

Table 3.2. Average annual change in real GNP (percent)

	1969-79	1979-89
Algeria	6.4	3.3
Iran	3.0	1.7
Saudi Arabia	13.3	.5

Source: WRI, 1992/93.

Table 3.3. Changes in land use

Country or group	land area, 1989 (thousand of sq. kilometers)	Share of total land area 1989 (%)				Average Annual growth rate 1965-89 (Agri. Land (%)
		Agri.	Perm. pasture	Forest and woodland	Others	
Algeria	2,382	3	13	2	82	0.5
Iran	1,636	9	27	11	53	-0.4
Saudi Arabia	2,150	1	40	1	59	1.9
MENA	11,305	6	22	3	69	0.1

Source: World Development Report, 1992.

building sites.

Agriculture in MENA not only suffers from lack of sufficient agricultural land, but also of aridity and soil condition. As indicated in Table 3.4, when soil with no physical and chemical problems is considered, more than 99, 62, and 96 percent of total land in Algeria, Iran, and Saudi Arabia, respectively, are arid. The maximum potential of arable land in the world has been variously estimated at between 2500 and 3000 million hectares. Table 3.5 indicates per capita cropland in the world and the MENA region. In 1986 world cropland available per person was about a third of a hectare, down from nearly half of a hectare in 1961, a very substantial drop of 32 percent in a quarter of century. The rate of decline in the MENA region was about 47 percent between 1961 and 1986. This means that, on average, in 1986, one hectare of cropland must feed over 3 people, while in 1961, one hectare of cropland must feed 2 people in MENA.

By 1986, some 15 percent of world cropland was irrigated, up from about 10 percent in 1960 (see Table 3.6). Irrigation, together with increased fertilizer application and improved seed varieties, has been the principal factor in increasing agricultural production in the 1970's and the early 1980's. More than half the increase in agricultural output in past 20 years came from new or rehabilitated irrigated area (Urban, 1989).

As the agricultural sector in developing countries moves from subsistence to

Table 3.4. Climatic classes and soil constraints

	Total Land Area (000 hectares)	Percent of Total Land Area: Arid	Semi-arid	Humid	Cold	Land with No Inherent Soil Constraints(a) (000 hectares)	Percent Arid	Percent Semi-arid	Percent Humid	Percent Cold
Algeria	238,174	92	3	5	0	96,958	99	0	1	0
Iran	163,600	76	17	7	0	14,785	62	28	9	0
Saudi Arabia	214,969	97	2	0	0	30,579	96	3	0	0

Source : World Resources Institute(WRI), 1992/93.
(a) No inherent soil constraints means soil that is not affected by the following constraints:steep slopes, shallow soil, slops, shallow soil, low nutrient retention, acid soils, low potassium reserves,and gravel.

Table 3.5. The cropland per inhabitant

	Per capita (ha) 1961	1986	Percentage change (%)
World	0.44	0.30	-32
MENA	0.58	0.31	-47

Source: Urban,1989.

Table 3.6. Total and irrigated cropland by region

	Cropland		Irrigated area		Irrigated as percentage of cropland	
	1961-65	1986	1961-65	1986	1961-65	1986
World	1334	1474	149	228	11	15
MENA	81	108	14	23	17	21

Source: Urban,1989.

commercial production, or in food deficit countries moves to self-sufficiency in food, the use of off-farm inputs increases along with the use of improved technologies. The increased use of off-farm inputs such as fertilizer and tractors reduces dependence on land resources (that is they have an important land substituting role) and in the MENA region, with agricultural land constraints, they play a vital role. Fertilizer use has become a sine qua non, as in other developing countries. In the MENA, fertilizer usage is projected to have a annual growth rate of about 5.4 in 1982/4-2000 (Alexandratos, 1988). This is lower than the historical growth rate of 7.8 percent during 1975-1985. This reflects unfavorable overall economic conditions, especially declining oil prices, limiting the possibilities to import fertilizers and provide subsidies for their usage. In the early 1980s, the MENA had the highest average fertilizer application rates among all the regions reported in Table 3.7. But within the MENA, especially the three countries included in this study, the fertilizer usage differed significantly both in amounts applied per hectare and in trends over time. For example, the intensity of fertilizer use in arable land and permanent crops in Algeria fell from 26.3 (kg/ha) in 1973 to 23.6 in 1978, while in Iran and Saudi Arabia the rate of application increased from 24 and 375 to 80 and 401, in the same period, respectively. After the third oil shock, when oil prices fell, the ratio was maintained in Algeria and Iran, while Saudi Arabia remarkably increased from 190.4 to 462.5 (see Table 3.8). For

Table 3.7. Fertilizers use in the region

	kg/ha		Growth rate,Total fertilizer (% per year)			
	1982/4	2000	961-75	1975-85	1980-5	1982/4-2000
93 developi ping countries	43	78	12.4	7.1	5.7	4.6
MENA	72	156	12.5	7.8	6.8	5.4

Source: Alexandratos, 1988.

Table 3.8. Consumption of fertilizer in kg. per ha. of arable land and permanent crops

	1961-65	1970	1973	1978	1983	1988
Algeria	7.2	16.5	26.3	23.6	22.1	22.5
Iran	1.6	5.9	18.8	21	69.9	69.5
Saudi Arabia	6.3	7.3	8.2	13	190.4	462.5

Source: FAO Fertilizer Yearbooks, various years.

farmers to receive timely and adequate amounts of fertilizer requires considerable investment in infrastructure for storage, transport and marketing. Previous investment in infrastructure and sustained agricultural expenditures, even during austerity, allowed Saudi Arabia to increase fertilizer consumption at higher rates after 1983. Raising staple food production in the MENA region was been given greater priority in 1980s via increased allocation share of fertilizer to principal groups of crops. For example, the shares of food grains (wheat and rice) and feed grains (mainly barley and maize) of fertilizer usage were 37.7 and 14.7 percent respectively, in 1882/4.

A feature of agricultural policy in the oil exporting countries in the region is the growing use of oil revenues for subsidy at the farm level. This is channelled through subsidy in the use of fertilizers, pesticides, improved seed, and herbicides. Due to lack of data on all these inputs, focus is made on fertilizers (mentioned earlier) and number of tractors in use in all three countries. Tractors provide considerably more power than, say, a bullock team, but they are dependent on sources from outside of the villages for spare parts and fuel. With such machinery, ploughing is often deeper than with traditional implements and can seriously disturb the soil structures. For example, in the MENA region with very arid condition, the practice of disc-harrowing can provide ideal soil conditions for wind erosion (Beaumont, 1985).

However, the absolute numbers of tractors can not convey a realistic indication of the intensity of mechanization within a country. A much better indicator is the numbers of tractors per unit of arable land planted with permanent crops. For example, in the early 1960s, as can be seen from Table 3.9, that ratio in Algeria was relatively high at 4 (because in North Africa, where European settlement was strong, tractors gained growing importance) while in Iran and Saudi Arabia the ratios were 0.7 and 0.4 at the same period, respectively. During the early 1970s, after first oil shock, massive investments were made in farm machinery in the region. By 1978 that ratio reached 5.6, 3.7, and 0.9 in Algeria, Iran, and Saudi Arabia, respectively. Even after the decline in oil price after 1983, the upward trend of the ratio in continued all three countries (see Table 3.9).

Food consumption and availability in early 1980s

Consumption and availability (domestic production + imports) of food are most important components of food security. In this section we analyze the consumption in the region in terms of per capita calories per day and indicate the share of cereals in total food consumption. Then the share of food production and food imports in total food available is examined.

As Table 3.10 shows, food consumption per capita (in calories) in the region had an upward trend in all three countries. It also indicates that the shares of cereals were high in total consumption in 1983/5, but as the per capita income levels increased these shares decreased.

Table 3.9. Tractors in use

		1961-65	969-71	1973	1978	1983	1988
Algeria	total number	27620	4233	49500	42147	50279	94000
	per 1000 ha of arable land & permanent crops(a)	4.0	1.1	6.9	5.6	7	12.5
Iran	total number	11300	20167	25000	55000	95000	113000
	per 1000 ha of arable land & permanent crops	.7	1.3	1.4	3.7	6.4	7.6
Saudi Arabia	total number	247	617	850	1000	1500	1850
	per 1000 ha of arable land & permanent crops	.4	.7	0.8	0.9	1.3	1.6

Source: FAO Production Yearbooks,various years.
(a) Ratio calculated by author.

Table 3.10. Food consumption and direct human use of cereals per capita(calories)

	total				By major commodities, 1983/5			
	1961/3	1969/71	1979/81	1983/5	Cereals	Roots and plaintains	Livestock	Other
MENA	2222	2371	2845	2985	1724	55	260	946
Algeria	1767	1825	2618	2712	1524	60	316	812
Iran	1968	2218	2883	3115	1880	60	277	898
Saudi Arabia	1832	1887	2827	3092	1324	19	540	1209

Source: Alexandratos,1988.

Increasing oil revenues in oil exporting countries during the 1973-80 period (see Table 3.11) not only generated much of the rapid increase in food demand, but also brought substantial shifts in food consumption patterns in the region. The per capita income in oil exporting countries increased rapidly at an annual rate of 10.5 percent (on the basis of constant 1980 US$) between 1973 and 1980. Based on Khaldi's study, this increment of per capita income from oil revenues alone contributed an additional 7 percent to total food consumption. Table 3.12 shows the consumption of total meat in all three countries increased at high rates over time. For example, Iran with 9% and Saudi Arabia with 12% experienced the fastest growth in consumption in the region in the late 1970s. Consequently, feed grains (e.g., barley) use also grew, exceeding the rate of grown in the consumption of food grains (e.g., wheat). Between 1966 and 1980, wheat consumption expanded at the annual rate 5.4 percent (55 percent of total utilization of basic staple food), while feed grains consumption increased with a 7.5 percent per year. Consumption of eggs in MENA in 1966-80 increased at 7.8 percent, annually. But in oil exporting countries the egg consumption nearly tripled by the late 1970s. This production-consumption gap in eggs made Algeria the world's largest importer of eggs in that period (MENA Outlook and Situation Report, 1984). Table 3.12 also shows the presence and increasing food production-consumption gap in all three countries. As Table 3.13 indicates, the self-sufficiency ratio (SSR) for major food

Table 3.11. Government oil revenues (million US dollars)

Year	Algeria	Iran	Saudi Arabia
1963	44	398	502
1964	65	470	561
1965	102	522	655
1966	145	593	777
1967	200	737	852
1968	262	817	966
1969	299	938	1008
1970	325	1093	1200
1971	320	1870	2160
1972	700	2308	3107
1973	1100	5600	7200
1974	3500	22000	29000
1975	4000	20500	27000
1976	4500	22000	33500
1977	5000	23000	38000
1978	5400	20900	36700
1979	8746	19186	62855
1980	12647	13286	105813
1981	12985	12053	116183
1982	10770	19233	75534
1983	9467	19255	42809
1984	9189	12255	34243
1985	9170	13115	24180
1986	4819	7183	16975
1987	6057	10515	19271
1988	4988	8170	20500
1989	3800	14000	16000
1990	12300	15240	40700

Source: the MIDDLE EAST and NORTH AFRICA, various years.

Table 3.12. Consumption and production of cereals, meat, and eggs 1966-70 and 1976-80 averages

			total cereals	total meat	eggs
			(1000 metri ric tons)		
Algeria	1966-70	prod.	1689.7	90.6	11.4
		cons.	2247.8	94.2	12.0
	1976-80	prod.	1789.5	132.5	18.1
		cons.	3765.2	147.2	49.7
Iran	1966-70	prod.	5928.7	285.7	48.6
		cons.	6128	290.3	49.4
	1976-80	prod.	7919.6	584.1	133.6
		cons.	10607.2	741.1	152.0
Saudi Arabia	1966-70	prod.	456.8	11.3	6.8
		cons.	755	35.7	10.2
	1976-80	prod.	321	27.9	19.1
		cons.	1690.7	215.2	32.6

Source: Khaldi,1984.

Table 3.13. Food self-sufficiency ratio for major food items, 1970 and 1981

	Cereals		Meat	
	1970	1981	1970	1981
Algeria	73	40	97	87
Iran	98	66	90	66
Saudi Arabia	22	7	38	27

Source: Shapouri,1984.

items (cereals and meat) decreased in 1970-1980 period in all three countries.

One of the most serious problems facing MENA is rising imbalance between consumption and domestic production of food. Rapidly escalating effective demand and sluggish domestic supply response have made MENA one of the least food self-sufficient regions in the world. Food security consequently dominates discussion of food policy in the region (Richards, 1987). As can be seen from Table 3.14, through the mid 1980s, the growth rates of demand for agricultural products, all uses, exceeded the growth rates of agricultural production in the region and in all three countries as well. The Table also shows the rate of decline of the self-sufficiency ratio (SSR) in all three countries was higher in 1970s than in the 1960s. Many countries in the region including oil exporting countries (e.g., Algeria), were food self-sufficient or nearly self-sufficient in the early 1960s.

The common reaction to the imbalance of domestic supply and demand for food was more imports. In Chapter V we discuss the causes of increasing imports of food in oil exporting countries. As Table 3.15 indicates, the growth rates of agricultural imports substantially increased after the first oil shock in 1973/4. Table 3.15 also shows the share of food imports in total imports. For example, the food import shares in Algeria and Iran increased markedly, making these countries more dependent on outside food suppliers, while in Saudi Arabia that ratio decreased in the same period.

Table 3.14. Growth rates of total agricultural demand and production and self-sufficiency ratios

	Growth in total demand (all uses) (% annually)				Growth in total production (% annually)				Self-sufficiency ratios (%)			
	1961-70	1970-80	1980-5	1961-85	1961-70	1970-80	1980-5	1961-85	1961/3	1969/71	1979/81	1983/5
Algeria	2.9	8.1	3.8	5.9	0.9	0.2	2.4	0.9	106	85	44	41
Iran	4.7	6.7	3.8	5.7	4.8	4.2	2.1	4.1	98	97	79	73
Saudi Arabia	6.1	14.3	11.7	11.7	3.1	5.1	20.8	7.2	64	59	25	32
MENA	3.4	5.3	3.8	4.3	3.0	3.1	2.4	2.9	101	97	80	76

Source: Alexandratos,1988.

Table 3.15 Growth rates of total agricultural imports and shares of agri.imports in total imports

	Growth rate in agri. imports (% annually)				Share of agri. imports in total imports (%)	
	1961-70	1970-80	1980-85	1961-85	1969/71	1983/5
Algeria	-1.4	14.8	7.0	8.1	16	21
Iran	0.8	19.0	7.1	13.5	9	20
Saudi Arabia	9.7	18.3	6.0	13.3	30	14
MENA	2.6	12.7	6.1	8.8	20	18

Source: Alexandratos,1988.

Food consumption and availability: 1981-1993

After 1980, some events such as invasion of Iran in 1981 and Kuwait in 1991 by Iraq and declining oil prices in mid-1980s had remarkable effects on production and imports of agricultural products in the region. The region's agricultural sector also continued to be affected by policy reforms, as a main part of adjustment economic policies, during the 1980s. Common features of the reform for many countries in the region have been the sharp reduction or elimination of guaranteed prices, the privatization of input supply, liberalization of agricultural trade, and a reduction or removal of input subsidies. The political instability problems in some countries (e.g., Algeria) not only prevented reduction of consumer price subsidies in basic food and bread, but also created disincentives for sustained private investment in agriculture. Weather continued to be a major determinant of farm output in countries with mainly rain-dependent agriculture (poor weather in North Africa, e.g., Algeria, reduced yields).

However, due to implementation of some agricultural policies and the high priority given to agricultural sector, most countries in the region in last decade increased their agricultural production. For example, cereals production had an upward trend and wheat production reached 44.3 million tons in the region in 1992. In spite of achievements in some countries in the region, the gap between production and consumption is still increasing, resulting in continued dependence on external supply sources to satisfy a fast-growing demand (UN and FAO, 1992). Therefore, the region was forced to import, for example, 22.8 million tons of wheat to meet wheat consumption in 1992. In 1992, imports of agricultural commodities in MENA were estimated at $29 billion, about 10 percent of global agricultural imports (Rosen and Parker, 1993). As mentioned in previous sections, due to decline oil prices in mid-1980 the growth rate of agricultural imports decreased. But it recovered in the late 1980s due to higher demand brought about rising oil export earnings and a continuing population growth rate of 3 percent. In the period 1983-1992, Saudi Arabia was the major MENA importer, followed by Egypt, Algeria, Iran, the United Arab Emirates (UAE), and Turkey.

Food consumption in the region increased by 5 percent annually in the 1980s. This is partly due to high population growth rate and partly due to government polices. The average daily diet for the region to over 3,100 calories, reflecting the higher income, subsidies on staple foods, policies limiting price hikes for foods not covered by subsidies, modernized and more efficient marketing, and urbanization (Rosen and Parker, 1993). Cereals (including wheat, feed grains, and rice) remain the most important agricultural imports to met the food production-consumption gap. The cereals self-sufficiency ratios in major food imports in the region ranged from 22 percent in Algeria to 99 percent in Turkey in 1990. Also, the MENA countries are highly depended on oil vegetable imports, with self-sufficiency ranging from 2 percent in Saudi Arabia to 62 percent in Turkey in

1990.

Wheat is the staple food of the region, and wheat imports are a use of major foreign exchange. To reduce or elimination wheat production-consumption gap most countries in the region have actively stimulated wheat production. Despite reduction in oil prices after 1983, some production policies in wheat including maintaining domestic wheat producer prices above world market, import restriction, and input subsidies have been continued. The producer support policies helped stimulate an average annual increase in wheat output of 3.3% in the Middle East and 3.8% in North Africa in the 1980-1992. Most of the increase was due to improved yields (Burfisher, 1993). Strong production gains relative to consumption growth rate have enabled the region to slightly increase its wheat self-sufficiency ratio. In 1992, Middle East wheat production equaled 91 percent of its consumption, compared to 80 percent in 1980. North Africa production equaled 39 percent of its consumption compared to 36 percent in 1980. Regional wheat self-sufficient reflects varying performance by individual countries. Saudi Arabia after 1984 has become a major exporter, exporting about one-half its crop. Productivity in the wheat sector in Algeria has been hampered by a shortage of inputs, an uneducated work force, poor marketing infrastructure, and lack of irrigation. Yields are low and harvested area declined nearly 25 percent between 1980 and 1991. Wheat self-sufficiency fell from 70 percent in 1970 to 31 percent in 1992 (Burfisher, 1993).

For the majority of oil exporting countries, petroleum provides most of their foreign exchange earnings. For example, the share of oil as a percent of total exports in the period 1986-88 were about 46, 84, and 92 percent in Algeria, Iran, and Saudi Arabia, respectively. As mentioned in the previous section, in the 1970s as oil prices rose sharply two times and oil export earnings from oil soared agricultural imports by the region increased dramatically. Based on study by Urban and Kurtzig (1993), the strong correlation between oil price and agricultural imports in the region diminished in 1980s, with the exception of Saudi Arabia, whose major investment in the agricultural sector has increased food self-sufficiency and somewhat reduced imports. Following the decline in oil price in 1983, the effects of oil price on agricultural imports and investment varied among countries. As Urban and Kurtzig point out, in general agricultural imports did not decline. In fact, they increased, although at a slower pace than in previous decade. In high income oil exporting countries such as Saudi Arabia, agricultural imports were not greatly affected. This was primarily because their oil exports revenue are 10 times greater than their agricultural imports bill. High middle-income and middle-income countries such as Iran and Algeria remained large food importers. In fact, due to the geo-political situation in the region, most governments in the MENA in spite of declining in oil prices in 1980s from 'national security' and 'food security' considerations are very reluctant to curtail public expenditure for defence and food programs.

Algeria: Physical Features and Natural Resources

Algeria, with 2,381,741 square kilometers, more than four-fifth of which is desert, is the largest of three countries in north-west Africa that comprise the Maghreb (with Morocco, and Tunisia), known as the region of mountains, valleys and plateaux lying between the Mediterranean sea and the Sahara desert. Most of Algeria's arable land is concentrated in the northern part of the country, between the Mediterranean Sea and the southern slope of the Saharan Atlas Mountains.

The climate of northernmost Algeria, including the narrow coastal plain and the Tell Atlas (the country's heartland) southward to the margin of the High Plateaux, is of "Mediterranean" type with warm, wet winters and hot, dry summers. The average annual rainfall on the coast is more than 500 millimeters. Rainfall increases as one moves east from Oran (360 mm.) to Algiers (more than 700 mm.). In the High Plateaux, the average is about 300 millimeters per year and decreases sharply as one moves farther south. As in many other MENA countries, precipitation is quite irregular and highly variable, not only from year to year, but also seasonally.

As a result of low and uneven rainfall combined with high rates of evaporation, the rivers tend to be short and to suffer large seasonal variations in flow. The longest perennially flowing river is the Oued Chelif, which rises in the High Plateaux and crosses the Tell to reach the Mediterranean Sea east of Oran.

The surface water resources are close to 13 billion cu. m. most of which is surface runoff running in seasonal streams. In 1990, 1.0 billion cu.m. were put to use by some 20 dams, while the rest drained to the sea. The annual ground water resources are estimated at about 2 billion cu.m, 1.7 billion cu.m. of which are put to use. The traditional water system contributes to the irrigation of 22 percent of the agricultural land (Baasiri, 1990).

According to the most recent population census, April 1987, Algeria has a population of 22,971,558 (this increased to 25.1 million in mid-1990, World Development Report, 1992). The great majority of the inhabitants live in the northern part of the country, particularly along the Mediterranean coast. The overall population density is about 10 persons per square kilometer. However, the average provides a misleading impression of the population density. Because of aridity and limited rainfall, the population density is enormously varied from more than 100 per square kilometer in north to less than one person in the middle of the Sahara.

Algeria has rich mineral resources and, even before the petroleum era, mined and exported high-grade iron ore, phosphate, lead, zinc, and antimony. Production of crude petroleum in Sahara on a commercial scale began in 1958. In early 1990 Algeria was producing more than 700,000 b/d. Algeria oil is light and with low sulphur content, which is attractive to foreign refiners. Proven reserve of petroleum at the end of 1988 were assessed at 9200 million barrels, sufficient for about another 39 year of production at 1988 levels. Algeria's proven recoverable reserves of natural gas, mostly nonassociated with oil reserves, are the fourth largest in the world after the former Soviet Union, Iran, and the United States.

Agricultural Development

Lower petroleum prices in 1983, cut Algeria's export earnings by 7 percent from the 1982 level. Despite the slip in hydrocarbon sales, the Algeria economy performed well in 1983. Real GDP increased 3% and per capita GDP increased from $1980 in 1980 to $ 2400 in 1983.

In 1983, cold winter and a drought in spring and summer stemmed the grain harvest at 60 percent of the average of the five previous years. Wheat production fell to 810,000 tons; imports of wheat reached 2.7 million tons, to cover projected consumption of 3.65 million tons in 1983/4. Based on FAO index of agricultural production, using 1979-81=100 as the base period, total agricultural production increased in 1983 and 1984 to 103 and 110. But when measured on a per capita basis it fell to 94 and 97 in 1983 and 1984, respectively. For livestock production, using the same base period, indices show an upward trend on both total and per capita basis, but the per capita trend is less impressive in the 1980-1984 period. The livestock production index, increased from 101 in 1980 to 127 in 1984, while on a per capita basis, it increased from 101 to 112.

Algeria's food subsidies, which reached $ 1.5 billion dollar in 1983, were not enough to significantly reduce the production-consumption gap. For instance, the 15 percent increase in the producer price of wheat in 1983 was offset by an increase in consumer price from 100 percent in 1980 to 132 percent in 1983. Therefore, the grain self sufficiency ratio fell during 1980-83 from 49 percent to 26 percent. In 1985, grain output was low, but continued to respond to improved producer incentives. New records were reached in poultry meat and egg production (MENA, Situation and Outlook Report, 1987).

During the 1980s, some adjustment to the centerlized economic strategy occurred in Algeria (see economic plan section in this chapter). Fundamental market-oriented economic reforms, of which agricultural reform is a cornerstone, have been undertaken since 1987. The food deficit, even in favorable harvest years, has been a major structural problem over past three decades (the State food and agriculture, 1991). Despite increased investment, agricultural output in the 1980s was poor, owing to drought. With high levels of food imports, agriculture is considered to be crucial in the future. The value of food imports has increased from about 11 percent of total imports in early 1970s to more than 20 percent in 1988, and by 1990 the country produced only 25% of its domestic cereal requirements. Total agricultural imports, consisting largely of wheat, coarse grains, dairy products, and edible oils, grew at an annual rate of 28 percent during 1970s, but showed little growth in 1980s (see Table 3.16). The Government aims to

Table 3.16 Algeria : Agricultural trade summary

Commodity	Total imports			Growth rates	
	1969-71	1979-81	1986-88	1970's	1980's
		$ million			percent
All merchandise	1164.9	10081.5	7930.0	24.1	-3.4
Ag. products	182.5	2097.9	2138.7	27.7	.3
Live animals	5.4	5.2	81.0	-.4	48.0
Meat & prep.	.5	40.7	30.8	56.4	-3.9
Dairy prod. & eggs	28.8	295.9	353.6	26.2	2.6
Wheat & flour	39.8	595.7	529.1	31.1	-1.7
Coarse grains	1.1	85.4	211.9	54.6	13.9
Edible oils	22.5	188.7	172.7	23.7	-1.3

Source : FAO and UN data.

achieve 80 percent self-sufficiency by the year 2000, when the population is expected to be about 37 million (MENA, 1992).

Algerian Agricultural Policies Review

Since independence in 1962, Algeria's agricultural sector has dominated economic and policy considerations. Algeria's development strategy of rapid industrialization has been made possible by petroleum and gas revenue and has emerged as the economy's engine of growth. On the other hand, Algeria's agricultural sector is small (only 3 percent of its land is suitable for cultivation) but important since it is responsible for producing food for people and employment for a large portion of the population (in 1990, agricultural population was 24% of total population) (see Table 3.17). Algeria faces two food security issues: failure to feed itself through its own agricultural production and its increasing inability to cover the cost of food imports and food subsidies (Swearings, 1992). The imbalance in Algerian economy, due to the strength of one sector, industry, that has been initiated by the weakness of another sector, agriculture, can be seen by considering the development plans.

Table 3.17. The importance of agriculture in the economy

	Agri. GDP % of total GDP				Agri.Pop. As % of total population		Agri. Imports As % of total Imports	
	1965	1978	1985	1990	1980	1990	1980	1990
Algeria	15	7	8	13	49	24	19	28
Iran	26	9	....	21	38	27	26	22
Saudi Arabia	8	17	3	8	60	39	13	19

Source: World Development Report and the State of Food and Agriculture, FAO, various years.

Agriculture and economic plans

The "industrialization-first" strategy has its theoretical roots in the notion of industrialization as articulated by Bernis, a French adviser to Algerian industry. He argued that given Algeria's limited agricultural resources, the rural population could not maintain a reasonable standard of living and therefore had to find employment in the industrial sector. In any case, history had shown that an agricultural revolution followed, never preceded, an industrial revolution (Entelis, 1986). The implementation of this strategy, industrialization first, was begun with a "pre-plan" (1967-69) with modest objectives. During three years the structure of a state-directed economy was created and most foreign assets were nationalized. The industrialization that began in the first four-year plan (1970-73) accelerated dramatically with a quadrupling of oil prices at the start of the second four-year plan (1974-77). Table 3.18 shows the sectoral balance in the Algerian economy during the first three plans, 1967-77. As can be seen from this table, actual investment in the agriculture and social infrastructure fell short of their planned shares. The bureaucratic system, due to the centrally planned policy, made it more difficult for the agriculture sector to reach its targets. Conflict in objectives of plans and inefficiencies caused the government to fall back to a single year plan for 1978. In the first two four-year plans, the bulk of investment funds went to heavy industry. Algeria started considering light industry and agriculture in the first five-year plan (1980-84), by allocating 12 percent of the budget for exploration of water resources and agriculture. The share to industry of total investment was reduced to 23.5 percent, compared to 45 percent in the (1970-73) plan. Policymakers called that investment strategy "planting Algeria's oil" since by using petroleum revenues they hoped to create a strong industrial base. The first five-year plan, 1980-84, was intended to overcome many problems, such as hyperurbanization, unemployment, and neglected domestic food production. Under the Benjedid regime that took power in 1979, Algeria moved toward reliance on market forces for resources allocation. Falling oil prices in the early 1980s, imbalances in earlier development strategies and concerns for preparing for "life after oil" forced Algeria to adopt a second five-year plan for 1985-90. Despite the fact that the absolute amount allocated to agriculture was nearly doubled, it would still represent only 14.4 percent of the total budget under the new plan. The yearly growth rate of investment in agricultural production was expected to be 4.5 percent and was insufficient to meet the rate of growing food demand (not the rate of growing population) that was in turn due to the high rate of increasing urbanization and per capita income (e.g., growth rate of total agricultural demand was, annually, 5.9 in the 1965-85 period).

In the mid 1980s, GDP (at current prices) in Algeria was 16 times its level at independence (1962), placing Algeria among the upper middle-income countries. The first oil shock in (1973-74) and the second oil shock in (1979-80) helped considerably in its development efforts. During 1985, the price of crude oil, which had been hovering around $30 per barrel began to slip. By the summer of 1986, the price had fallen below $10, and in early 1987 recovered slightly. The catastrophe was compounded by the rapid fall in the value of the dollar, which lost more than 40 percent of its value against European currencies. It was these currencies that Algeria depended on for roughly two-thirds of imports that came from the Common Market (Ruedy, 1992). In the 1980s, GDP growth slowed and then turned negative (see Table 3.19). The state budget fell to a state of chronic deficit in 1986, helping trigger double-digit inflation that was worsening as the decade ended. Unemployment grew to 25 percent by 1988 and per capita consumption fell.

Agricultural policies and food security crises

Food riots are the most ominous symptoms of the food security crisis in North Africa today. Week-long riots in Algeria during October 1988 were a part of this common pattern. As a symbol, during the riots, the Algerian national flag over a prominent government building was replaced with an empty wheat sack. The Algerian food security crises was rooted in the variability of domestic food production and oil revenues that finance food imports. Also, the conflicts and trade-offs between the goals and tools in agricultural policies for self-sufficiency through increasing domestic production on the one hand and the role of imports in supplying the food requirement of the population on the other may contribute to the

Table 3.18. Planned and actual investment, 1967-1977

	1967-69		1970-73		1974-77	
	Planned	Actual	Planned	Actual	Planned	Actual
			(percentage)			
Hydrocarbons	41.9	50.9	36.9	47.1	40.6	48.6
Capita goods	47.0	40.6	48.9	46.2	47.6	44.5
Consumer goods	11.1	8.5	14.2	6.7	11.8	6.9
Total industry	48.7	55.3	44.7	57	43.6	62.0
Agriculture	16.9	16.4	14.9	13	13.2	4.7
Infrastructure	34.4	28.3	40.4	30	43.2	33.3
Total	100	100	100	100	100	100

Source: Lawless, "Algeria: the Contradictions of Rapid Industrialization," in North Africa: Contemporary Politics and Economic Development (1984).

Table 3.19. Percentage growth of GDP in Algeria

1984	1985	1986	1987	1988
5.2	2.7	0.6	-1.4	-2.7

Source: IMF, International Financial Statistics (1989).

food security crises. To analyze the failure of the agriculture sector, we explain, briefly, the agricultural goals and the means to achieve them.

Analysis of failure in agricultural policies

Given physical limitations in Algerian agriculture, why, in spite of the Algerian government's long-standing emphasis on food self-sufficiency, has the country's food situation become so precarious? The role of the major contributing factors is clear, grouping those under three factors: insufficiency of investment, asymmetry of sector, and government pricing policies.

1. Shortage of investment for agricultural development. Despite the ideological and political significance of the agrarian sector in post-revolution Algeria and despite food self-sufficiency as a main goal in agricultural policies, the agricultural sector has been allocated only a small portion of total development funds. Paradoxically, the consideration given to agriculture has been decreasing while the consideration given to national food security has been increasing. For example, in the 1967-69 plan the share of agriculture was 25.8 percent of total investment. This percentage dropped to 14.8 percent in the 1980-84 plan (Swearing, 1992). This share in the 1985-89 plan was only 5.5 percent and, in fact, the additional share, that was allocated for water development 7.5% mainly went for dam construction, mostly to provide water for urban-industrial purposes. As Swearingen

pointed out, this shortage of government funding for agriculture has produced a panoply of conditions that have been highly inimical to food production and this shortage has been one of the major reason why Algeria's food security situation has become so precarious and problematic.

2. Asymmetry of sector. There are imbalances not only between the industrial sector and the agriculture sector, but also within the agricultural sector itself. These imbalances are rooted in government controlled and privately held lands. Algerian agriculture is comprised of three sectors: the socialist, the agrarian revolution, and the private sector. The socialist sector emerged in 1962-63 when the Ahmad Ben Bella government nationalized the abandoned colonial farms and provided for government-regulated "self-management." Until 1972 when that state sector was extended, the self-managed farms received the vast majority of the funds accorded to agriculture. The agrarian revolution was initiated in the early 1970s, to redistribute land holdings in the nonsocialist sector. It was expected that the agrarian revolution was a way both to benefit landless and land-poor farmers and to help the country meet its critical goal of agricultural self-sufficiency by 1980. In 1973, the agrarian revolution entered its second phase, that of redistributing over 650,000 hectares of private land to 60,000 landless peasants (fellahin). Those receiving land were to be granted permanent use of it, on condition that they belonged to one of the new cooperatives. Through these they were to be

given government loans and assistance in the form of fertilizers, seed, and farm machinery. By early 1979, 22,000 absentee landlords had been obliged either to cultivate their land or to turn it over to peasants, and more than 6000 agricultural cooperatives had been established (MENA, 1992). Unfortunately, the Algerian government's commitment to agricultural self-sufficiency temporarily fell by the wayside in the mid 1970s, when the quadrupling of world oil price in 1973-74 produced a huge windfall of oil revenues. The Algerian government began to rely on these unexpected revenues both to finance industrialization and to cover the cost of food imports. The new regime of Benjedid government introduced sweeping changes both in the public and private sector. In 1980, the government made credit available for the first time to private farmers and also allowed them more freedom in marketing their output (USDA, 1983). A new bank, the Bank of Agriculture and Rural Development (BADR) was established in 1983 expressly to serve the rural areas and the agriculture sector, improving agricultural production whether socialist, state-owned or private. One of the first projects that BARD focused upon was heavy lending designed to make Algeria self-sufficient in egg and poultry production.

From 1986 to 1988, the government allowed agricultural prices to rise, thus increasing incentives to farmers. It reduced subsidies on basic consumer goods in order to cut the fiscal deficit and encouraged state firms to set their own prices, thereby letting supply and demand determine the allocation of resources (Roe, Roy, and Senyupta, 1989). Following OPEC's decision in December 1985 to campaign for a "fair share" of the world oil market, the slump in oil prices gave an added pressure to promotion of non-hydrocarbon exports. For example, in 1987/88 Algerian non-hydrocarbon exports reached 2500 million dinars, 2000 million dinars short of the targeted figure in the 1985-89 plan. The adjustment policy, including raising administered prices, cutting imports by fiat, and diversification of exports reduced GDP growth to 1 percent in 1986 and 1987 and created a decline in per capita GDP. However, agrarian reforms may have allowed for higher returns to the farmer in the countryside, but their effect on the price of foodstuffs in the urban areas had been troublesomely, especially for the poor (Rummel, 1992).

3. Pricing Policies. Since independence, the government has successfully maintained low producer prices in its self-management sector. For example, when adjusted for inflation, government prices for staple food crops, such as wheat and barley, held practically constant from independence after 1976, despite major increases in the cost of imports (Bendrari, 1982). According to a World Bank study, the producer prices for these crops were only one-fifth to one-half of what they would been without government price-fixing (Cleaver, 1982). In addition, until the late 1970s, these prices were far below world market prices. The government has two motives for

maintaining low producer prices: first, to provide subsidized, cheap foodstuffs to industrial workers, and second, to provide inexpensive food for the urban poor, which is important for internal security. The price policy, sometimes called "dilemma pricing" greatly discouraged production of cereals and other price-controlled staple foods. Farmers tended to grow only enough food for their own consumption, earning money outside their farm (rugs and carpets, etc.) for other needs. By contrast, more prosperous farmers tend to invest in production of higher value speculative crops instead of investing in cereals or other basic food crops.

There are two ways to increase agricultural production: by increasing area and by increasing yield. A study by USDA indicates that Algeria in cereal output has not responded in relation to high-value agricultural products. For example, average area and yield response to producer price for green bean and wheat in the 1975-87 period were 3.47 and .16, respectively.

In summary, from independence in 1962 until recently, Algeria pursued a socialist path of development, emphasizing industry and rigid price controls, while exporting oil and gas, with a per capita income of $2060 in 1990. The growth of GNP had a downward slope in the 1980s. The economy depends on oil revenues, and when oil prices fell in 1985 it cost Algeria 15 percent of its GNP in lost revenues. This dependency on oil and gas for 98 percent of its foreign exchange and increasing dependency on foreign food has made the food security situation in

Algeria dangerous. By increasing investment in agriculture and instituting a more efficient pricing policy, the country might be able to achieve its agricultural goals, such as wheat self-sufficiency, or at least stop the downward trend in its production.

Wheat, which accounts for 55 percent of Algeria's cereal production and nearly two-thirds of the average daily caloric intake is a critical commodity in any plan for food self-sufficiency. The hope is that an appropriate agricultural policy, i.e., realistic goals and suitable means, such as a price policy, more comprehensive than that instituted in the mid 1980s under the banner "truth in pricing," will stimulate agricultural production and thus help the country to achieve food security.

Iran: Physical Features and National Resources

Iran is a large country with a total area of 1,648,000 square kilometers. It is a one of the world's most mountainous countries, consisting of an interior plateau, ringed on almost all sides by mountain zones of varying height and extent. The Iranian plateau is triangular, set between two depressions--the Caspian Sea to the north and the Persian Gulf to the south. Two great deserts, the Dasht-e Lut and the Dasht-e kavir, occupy a large part of the central plateau and together account for one sixth of total area of Iran.

The climate of Iran is one of the great extremes. Owing to its southerly position, adjacent to Arabia and near the Thar Desert, the summer is extremely hot, and in the southwest accompanied by high humidity. Most of Iran is arid, but in contrast, parts of the north-west and north receive considerable rainfall, up to 2000 m. m. along parts of the Caspian coast. The Caspian shore is hot and humid. This region is by far the most densely populated of the whole country. The extreme east and south, where rainfall is very scanty, were for long extremely lightly populated, except in the few parts where nomadic groups settled due to availability of water. The water shortage is intensified by unequal distribution of water owing to the seasonal rainfall pattern. According to most recent estimates, surface water in Iran is about 85,000 million cu. m, only 71% of which is used in agriculture (Jomhori Islami, 1993). To make the best use of the limited amounts of water, the Iranians centuries ago developed man-made underground water channels called "qanat" which are still in use. The main advantage of the qanats is that its underground location prevents most of the evaporation to which water carried in surface channels is subject. The country is also under constraint in regard to cultivated land resource. More than half of Iran's land surface (165 million hectares) is uncultivated.

The 1988 agricultural census reported that there were 56 million hectares of cultivable farm land, 16.8 million hectares of which are actually being cultivated. Some a 9 million hectare of cultivated area is dry-farmed, purely dependent on water supplied by rain. This farming system is predominated in the western area of the country (MENA, 1992).

According the national census, the 1986 population of Iran was 48,181,463. This total included 2.6 million refugees from Afghanistan and Iraq. Based on World Bank Report (1992), the country's population reached 55.8 million in mid-1990, and government records indicates that the number of refugees living in the country reached 4 million in 1992. Its population annual growth rate, 3.6 percent in the period 1976-1986, puts Iran's population growth among highest in the world. The average population density for the country was 32.9 persons per square kilometer at mid-1989. In some regions, such as Caspian coast, it is significantly higher than the national average, while in the more arid regions of Central plateau and south-west it is 12 or fewer persons per square kilometer.

Apart from oil and gas, Iran's mineral wealth includes chromite, lead, zinc, copper, coal, gold, tin, iron, manganese, and tungsten. Iranian copper deposits are among the world's largest (Iran a country study, 1989). Iran's non-oil mineral export were valued at $ 90.2 million in 1988. Based on 1989 data, the proven crude oil reserves in Iran were estimated to be 92.9 billion barrels at year-end, and based on 1987 production rate, it is expected to continue for more than 96.5 years. With proven reserves of 14,000,000 m. cu. m, Iran is the world's second richest country in gas resources, 12.6% of the global reserve.

Agricultural Development

In 1983, oil revenues which was about 19 billion dollars provided funds for strong upsurge in imports needed for the war with Iraq. Erratic rainfall in the winter and spring of 1982/3 lowered wheat and barley yield. This situation, plus reduced availability of fertilizer, chemicals, and machinery, party due to port and transportation difficulties, caused a decline in agricultural production in 1983. The indices of FAO show that the agricultural production fell from 106 in 1982 to 100 in 1983, on per capita basis, using 1979-81 as base period. Despite a high procurement price for wheat (about $250 per ton), plus easy credit, some of most fertile irrigated land was shifted from wheat to vegetables (e.g., watermelon) and alfalfa. Therefore, total cereals production decreased from 10,261,000 tons in 1982 to 9,255,000 tons in 1983. A drop in grains output is reflected in the lower government procurement of domestic wheat, which was about one million tons in 1977 and 1981 but dropped to 60 percent of that volume in 1983 (probably due to the declining purchasing power of the rial, transportation problems and rising non-governmental market prices) (MENA, Outlook Situation and Report, 1984).

The output of livestock in 1982 was about a third below the 1978 peak. A modest rebound occurred in 1983 as more imported feed grains were distributed to cooperatives. Meat production, for example, increased from 682,000 tons in 1982 to 697,000 tons in 1983.

Iran's economy rebounded in 1985, as some industries in the war area previously occupied by Iraq reopened and agricultural production recovered from the deep drought of 1984. Lower oil prices were not fully offset by higher volume, and total oil export earnings declined to $13 billion in 1985 from $19.2 billion in 1983.

In 1985, agricultural production rose about 8 percent, following a 4 percent decline in 1984 when drought reduced yields in western Iran. Wheat output rebounded 18 percent and reached 6.6 million tons. Prices of wheat, barley, and rice were above world average at the official exchange rate (MENA, Outlook and Situation Report, 1986). Output of livestock rose about 4 percent, based on FAO indices, from 117 in 1984 to 123 in 1985, but shortages of meat and eggs remained severe.

Iran's oil export earnings dropped to only $7.2 billion in 1986. The value of Iran's total imports declined from $11.63 billion in 1985 to $10.52 billion in 1986. Favorable weather and greater use of improved seed and farming methods contributed to a 8 percent increase in agricultural output. Cereal production increased from 10.79 million tons in 1985 to 12 million tons in 1986. The agricultural production indices were 113, 115, and 119 in 1984, 1985, and 1986, respectively. The greatest weakness in Iran's agriculture lies in the livestock sector. Meat production in 1983 increased to 720,000 tons, but still was below 1978's (before Islamic Revolution) 738,000 tons. The per capita index of livestock, using

1979-81=100 as base period, shows an increase to 100.44 in 1986. Then it fell to 99 and had a flat trend by 1990.

Agricultural consumption during 1980s increased. For example, wheat consumption, for all uses, increased from 6.8 million tons in 1980 to 10 million tons in 1990. The per capita consumption of cereals grew annually by 3.7 in the 1980-1987 period. In the mid-1980s, the economy deteriorated markedly following several significant events: the ensuring nationalization of many industries, the costly war with Iraq, the imposition of trade and financial sanctions from the West, and the decline of oil prices. Farm sector gains stemmed from positive government support and the fact that shortages of capital and foreign exchange had less negative impact than on other sectors. Pricing, credit, and subsidy polices increased productivity, food security, and rural welfare (Developing Economics, USDA, 1990). However, despite the support of import substitution policy in agricultural production in 1980s, Iran continues to be dependent on imports of cereals, as well as other foods. In the 1980s, major farm product imports were cereals, meats, edible oils, dairy products, and sugar. Due to problems and agricultural policies mentioned above, the growth rates of almost all items in food imports declined in the 1980s in comparison with 1970s rates (see Table 3.20).

The Iranian economy experienced turbulent events beginning with the revolution in 1979, leading to the creation of the Islamic Republic of Iran. Among others, these included a protracted and costly war with Iraq, various trade and financial sanctions imposed by the West, and instability of the world oil market. These developments brought profound institutional and structural changes in the economy, one of which was the growing significance given to agriculture. Article 43 of the new Islamic Constitution specifies a number of "regulations" on the basis of which the Government must "achieve independence in national economy", uproot poverty and impoverishment, fulfill growing human needs, including food, and securing employment. The new Constitution also makes "systematic and sound planning" a tool of economic management (Article 44). The agriculture sector provides food and employment to a large part of the population (see, again, Table 3.17) and became an "axis of development" and is considered important in economic development plans.

Agricultural Policies in Development Plans

Iran is characterized as an oil based economy and it might be fairly asked why agricultural development should be a matter of concern in a country that is blessed with large oil and gas resources and substantial revenue arising from oil exports. In the long-run, relying on a nonrenewable source (i.e., oil) with variable revenue means no guarantee for economic growth in the future. Experience, both in Iran and elsewhere, suggests that for oil based economy development would be assisted if agriculture were made profitable and productive (Meier, 1976).

Table 3.20. Iran: Agricultural trade summary

Commodity	Total imports 1969-71	1979-81	1986-88	Growth rates 1970's	1980's
	$ million			percent	
All merchandise	1766.7	11938.5	9863.7	21.1	-2.7
Ag. products	165.8	2266.8	1792.0	29.9	-3.3
Live animals	7.2	75.4	15.2	26.5	-20.5
Meat & prep.	7.2	298.1	267.0	45.2	-1.6
Dairy prod. & eggs	11.4	352.2	186.9	41.0	-8.7
Wheat & flour	26.3	201.9	356.6	22.6	8.5
Coarse grains	5.3	200.5	101.3	43.7	-9.3
Edible oils	38.7	308.1	193.4	23.0	-6.4

Source: FAO and UN data.

Agriculture has a particular importance as a sector for development because it is able to absorb a relatively large number of workers at low unit cost. This reason is even more important if we consider the high growth of the population and the demographic pattern of Iran.

By 1992, the Iranian government had implemented seven development plans five before the Islamic Revolution (1979) and two plans after the revolution. Since our analyses in this study cover 1960-1991, and the third plan was the first comprehensive plan, we start our analysis with the third plan.

The third development plan (1963-67)

Traditional agrarian systems are generally associated with outmoded methods of production, low land and labor productivity, and rural poverty and inequality. This is especially true for the traditional tenancy systems which covered most agricultural land and population in the developing countries of Asia and the Middle East. The Iranian agrarian system in the early 1960s was such a system (Amid, 1990). In the third plan, primary emphasis was placed on the growth target of 6 percent annual growth in GNP, increased employment possibilities, more equal distribution of income, stabilization of prices and equilibrium in the balance of payments.

The most important policy action in the agricultural sector during the 1960s was the adoption of a major land reform program something that was not even mentioned in the 1963-67 development plan. The official claim for the program was that it would boost production by freeing the agriculture sector from the fetters of the "feudal" land structure and ultimately benefit the "great mass of needy" peasants. The Shah's land reform program mirrored the principal characteristic of his modernization or Westernization policy. It failed to take sufficient account of the actual factors and specific structures of land tenure that were hindering development and failed to recognize the potential for development in the traditional structure of Iranian village (deh), instead pursuing an extreme reform course that was inconsistent and contradictory (Schirazi, 1993). Between 1962 and 1974, the number of peasants who became landowners as a consequence of land reform program was 1,766,625. It increased from one- third to two-thirds of total peasants who were landowners. It increased from one-third to three-fourths the amount of total arable land under cultivation. As Schirazi mentioned, land reform smashed the traditional organizational structure of agrarian production in Iran without replacing it with a new and adequate one. For example, it changed the village system (deh), which regulated the relationship of the peasants to the land and water as well as to one another as cooperating producers. That system was broken by land reform and replaced with a fragmented holding system that proved unworkable without sustained assistance from the government for the provision of crucial inputs such as irrigation and credit. Due to the limitations of space and scope in this study, we will not evaluate the land reform here. However, as Karshenas (1990) says: "The

Shah's land reform, a reform from above, originated in economic and political developments outside Iranian agriculture itself. The implemented reform took more than a decade to be completed. Minimal participation of the peasantry at the village level amounted to a surgical operation whereby the absentee landlords were removed from the apex of agrarian socio-economic hierarchy, without creating major changes in the distribution of holding and with minimum disturbance at the village level". Moreover, there was a major departure from the objectives of the plan in areas of irrigation projects, which due to the land reform, absorbed at least 13.6 percent of total expenditure on agriculture and irrigation. As a result of this change in objectives and means, 80 percent of the actual investment in irrigation was absorbed by large-scale and capital-intensive dams (which were stressed in the second plan; the third plan claims to change this emphasis). Only 4 percent of funds were allocated to small dams and "qanats" (a traditional irrigation method) with minimum dependence to outside technology. On the other hand, in the third plan only 1 percent of total expenditure in the agriculture sector was allocated to training and research. Mofid (1987) mentioned that construction of prestige-giving projects seems to have been more important than investing in people. The original, revised, and final allocations of the third plan are shown in Table 3.21. As shown in the table, within the sectoral allocations of the public investment programe, agriculture, industry and services were equally emphasized. However, the planned 4.1 percent growth rate of agriculture, the only sectoral growth rate to be included in the plan as a target, was not achieved. Agricultural growth reached only 3.0 percent.

The fourth development plan (1968-72)

The overall objectives of the plan can be summarized as:

1. To increase the rate of economic growth by gradually increasing the relative importance of industry, through raising its productivity;

2. To achieve a more equitable distribution of income through employment and welfare policies;

3. To decrease the nation's dependence on foreign countries in meeting its basic requirement (needs), this coupled with a diversification of exports.

Contrary to previous plans, the period of the fourth plan saw no wild fluctuations among the social, political, and economic variables and no exogenous shocks to the national entity. As the data in Table 3.22 show, in contrast to previous plans, the industrial sector received the highest priority, i.e., 20.3 percent of actual expenditure as compared with 8.4 percent in agriculture. The fourth plan was to increase real GNP by 9.3 percent per year. It was expected that foreign exchange receipts during the plan would be $9,448 million (in current prices), $7,032 million of which was to be from oil revenues. As can be noted from Table 3.22, the outstanding feature in that plan belongs to services, especially transport and communications. Agriculture in comparison to other sectors was the "poor

Table 3.21. Sectoral distribution of planned and actual public development outlays by the public sector during the Third Plan period (1962-67) (Billion rials)

	Planned						Actual	
	Plan Frame (at '60 prices)		Plan Frame (Revised)		Final allocations (at current prices)		(at current prices)	
	Amount	%	Amount	%	Amount	%	Amount	%
Agriculture & Irrigation	41.8	22.0	45.0	22.5	49.0	21.3	47.3	23.1
Irrigation	(11.8)	(6.2)	(16.5)	(8.2)	(22.0)	(9.6)	(21.7)	(10.6)
Industry and Mining	34.5	18.1	21.9	10.9	29.1	12.6	17.1	8.3
Power and Fuel	19.2	10.1	27.0	13.5	35.0	15.2	32.0	15.6
Transport & Communications	46.2	25.3	50.0	25.0	60.0	26.1	53.8	26.3
Housing and Construction					13.0	5.7	12.2	6.0
Social Affairs	(40.9)	(21.5)	(48.6)	(24.4)	(43.9)	(19.1)	(42.2)	(20.7)
Education	15.7	8.3	17.9	9.0	18.0	7.8	17.5	8.6
Manpower	5.3	2.8	8.0	4.0	3.3	1.4	2.8	1.4
Health	12.3	6.5	13.9	7.0	13.5	5.9	13.2	6.5
Urban development	6.0	3.1	8.0	4.0	7.5	3.3	2.7	3.5
Statistic5	1.6	0.8	0.8	0.4	1.6	0.7	1.5	0.7
Unspecified	5.6	3.0	7.5	3.7	-	-	-	-
Total	190.2	100.0	200.0	100.0	230.0	100.0	204.6	100.0

Source: Mofid, 1987.

cousin". This unbalanced growth strategy had a negative effect on agricultural sector performance. The agricultural sector's growth was slightly faster than the population's, 3 percent annually, in the third plan periods. This agricultural growth was different among different products. For example, the cash crops like cotton and raw sugar were mostly responsible for the growth rate. The growth of wheat and barley during the fourth plan periods were -1.9 and -7.0 percent, respectively (Table 3.23).

Finally, during 1968-72, agricultural production was not sufficient to satisfy domestic needs and about 79.6 billion rials agricultural products were imported. Table 3.24 shows the relative decline of the agriculture sector as a share of GDP (in constant 1959 prices). That is, during 10 years the agriculture share of GNP fell from 26.6 percent to 16.1 percent in 1972.

The fifth development plan (1973-1977)

The fifth plan was basically a continuation of the fourth plan, since the first oil shock took place in 1973-74 and it was the last plan of the Shah's regime. Analysis of this plan is very important to understanding economic reasons for the Islamic Revolution in 1979 and most recent economic policies in Iran. Even though the initial fifth plan was very ambitious, it was abandoned in favor of an even more ambitious version as oil prices rose in the last quarter by about four fold. The oil revenue which was $2,400 million in 1973 jumped to $5,066 million in

Table 3.22. Sectoral distribution of planned and actual public development outlays during the Fourth Plan (1968-72) (billion rials: at curmt prices)

Sector	Approved Credits		Final Revision	
	Original (Amount)	Share %	Amount	Share %
Agriculture	60.5	13.2	46.7	8.4
Industry & Mines	98.9	21.6	115.6	20.9
Oil and Gas	26.3	5.8	61.7	11.1
Water	48.5	10.6	45.3	8.2
Power	38.0	8.3	42.2	7.6
Transport & Communications	79.6	17.4	84.3	15.2
Telecommunications	20.3	4.5	46.5	8.4
Rural development	8.8	1.9	10.3	1.9
Urban development	7.0	1.5	9.1	1.6
Housing & construction	23.0	5.0	43.0	7.8
Education	19.4	4.3	19.0	3.4
Culture	1.8	0.4	1.5	0.3
Tourism	3.6	0.8	3.5	0.6
Health	12.4	2.7	15.7	2.8
Social Welfare	4.9	1.1	5.7	1.0
Statistics & other	4.1	0.9	4.4	0.8
Total	457.1	100.0	554.5	100.0

Source: Mofid, 1987.

Table 3.23. Agricutural output and growth (1968-72)

	1968	1969 (1000 tons)	1970	1971	1972	Annual average growth rates (1968-72)
Wheat	4400	3900	3800	3870	4034	-1.9
Barley	1160	1200	1200	800	800	-7.0
Rice	1000	1046	1138	1046	1015	.4
Cotton	160	155	150	148	208	6.7
Sugar	478	540	566	580	625	6.9
Meat	240	252	240	239	263	2.4
Milk	1900	1800	1900	1900	1900	1.0

Source: Mofid, 1987.

Table 3.24. The Distribution of GDP by sector (%)

	1962	1967	1972
Agriculture	26.6	20.9	16.1
Manufacturing & mining	12.4	13.6	13.4
Services	35.9	35.2	37.4
Oil	20.2	24.0	26.7

Source: Mofid, 1987.

1974 and reached $21 billion in 1975 (Rashidi, 1992). These higher oil revenues allowed some revisions in the development plan. This revised version was prepared hastily and with great optimism over future oil revenues. The main objectives of the revised fifth plan (1973-77) can be summarized as:

1. To raise the quality of life for all social groups;
2. To maintain rapid, balanced, and sustained economic growth, together with minimum price increases;
3. To fully utilize foreign exchange resources so as to remedy domestic shortages and check inflationary pressures, for foreign investment and for the creation of sources of national wealth to replace the depletion of oil resources over time.

More specifically, the plan was based on an overall growth target in real GNP of 25.9 percent annually. When the expected population growth rate of 2.9 percent per annum is considered, the target per capita GNP growth rate amounts to 22.3 percent. Data shows the growth targets for the value added of each major sector at 1973 prices. The average annual growth rate for oil output was set at 15.0 percent and agriculture was once more the very "poor cousin" at 7.0 percent. In fact, more than 50 percent of growth belonged to the oil sector (51.5%). When comparing the figures given in the original and revised plans, we can note that the projected total receipts rose over 148 percent. However, the Iranian budget, which had consistently registered a surplus, showed a deficit in 1975. Two reasons can be cited: (a) total expenditures were rising at an increasingly rapid rate and (b) the oil revenues were not rising at the anticipated rate (oil revenues had a shortfall of 19.5%). The shortfall in oil revenues and resulting budget deficit forced Iran to turn to the international money markets for survival (143.8 billion rials were borrowed in 1977). The financing of the deficit and cost-push pressures increased prices by 25.1 percent in 1977. Food prices were perhaps one of the most important elements in this cost-push inflation during this period.

It is a well documented fact that the agricultural sector during the fifth plan, as in other plan periods, was neglected. The disproportionate emphasis on agribusiness was not in harmony with Iran's agricultural tradition and culture [see, for example, Katozian (1981)]. We will concentrate our attention on the consequences of agricultural policies during the fifth plan in agricultural domestic production and imports, as well as in major agricultural prices. As can be noted from Table 3.25, between 1973 and 1977, on average, the price of food increased by 13.3 percent annually. The highest price increases were recorded for meat products (18.5%). As in other oil exporting countries, Iran's government heavily subsidized food prices ($1 billion a year from 1974 to 1976) significantly reducing the inflation rate for food. On the domestic production side, the production of staple crops (including corn) had a positive growth rate, while industrial crops' negative growth rate worsened between 1973 and 1977. These figures, in absolute terms and in isolation, may be misleading if we do not consider the trends in population growth during the plan periods. Between 1973 and 1977, population grew at 2.7 percent per year. Table 3.26 shows the growth rate of total food production during the same period. The table indicates that during 1974/5 and 1977/8, total food production grew by 4.1, 5.5, -3.5, and 5.6 percent annually. The annual population growth rate, on average, was 2.7 in the same periods (Mofid, 1987).

Moreover, as mentioned by Katuzian (1981), given the general neglect of the agricultural sector and poor policies by the government, such as the forced settlement of nomadic populations (a major source for domestic livestock production) and monopolization of pastoral land by the state, the total number of livestock in Iran during the plan periods declined. The facts and figures for the period under study show that even though agricultural production and imports increased much faster than the rate of population growth, the country faced food shortages and price increases. The following is an attempt to outline some of the reasons for such an outcome.

As a result of its agricultural and industrial policies, especially after the first oil shock in 1973-74, there was a significant internal migration from rural to urban areas. It has been observed that in the fifth plan period the rural exodus reached an average of 25,000 per year. These migrants were transformed from net producers to net consumers of food in a market which was already stretched. This would not have been a source of problems if the market were able to provide and distribute food adequately and efficiently. But, given bottlenecks in the infrastructure and as

Table 3.25. Annual average changes in consumer price index for agricultural products: 1973-1977 (%)

	1973	1974	1975	1976	1977	Average
Food	8.3	19.2	5.6	12.9	20.6	13.3
Dairy products & eggs	-0.1	16.6	6.2	8.9	13.7	9.1
Bread & rice	5.1	24.1	1.9	14.2	22.0	13.5
Meat & poultry	22.3	25.8	6.2	14.3	21.6	18.5

Source: Central Bank of Iran, 1977.

Table 3.26. Growth rates of total food production
percent per year (%)

Period	average
1967-70	5.0
1970-78	3.2
1970-74	4.8
1974-75	4.1
1975-76	5.5
1976-77	- 3.5
1977-78	5.6
1974-78	2.9

Source: Mofid, 1987.

there were too many activities taking place simultaneously in all sectors, the market was not able to cope with the rapid increase in demand. In addition, due to increases in oil prices and oil revenues, the wages increased in the cities, further increasing food demand. A great quantity of agricultural products was wasted through bad storage and inefficient transport and marketing practices. Based on one estimation, this wasted food production was about $2 billion during the fifth plan (Graham, 1980). In summary, food-price inflation was mostly due to structural inefficiencies and excessive waste contributed to large-scale food shortages. In the fifth plan, the growth rate did not exceed 4.6 percent.

Agricultural policies in post-revolution development plans

The Islamic government that took power in Iran after the Revolution of 1979 was determined to change the orientation of socioeconomic policies that prevailed under the Shah's regime. Since 1979, the government attached the highest priority to the rehabilitation and development of the agricultural sector, and policies have been aimed at increasing productivity, food security, and rural welfare. A number of internal and external factors constrained progress toward these goals. These included the invasion of Iran by Iraq in 1981, interruptions in the supply of domestically produced agricultural machinery, cuts in development expenditures, recurrent droughts, and uncertainty over property rights. Generally, the agriculture sector performed better than the rest of economy during the 1980s, primarily due to the positive public attitude toward agricultural development that was declared to be the "axis of development" and the fact that shortages of capital, skills, and foreign exchange (due to capital flight after revolution) affected this sector relatively less than other sectors. Rapid population growth and food subsidies in the country have created dilemmas for the management of the agricultural sector as a source of food supply. In this section, we discuss the agricultural policies after the Islamic revolution for 1981/82 and for 1987/88. This period includes two years after the revolution and the first Islamic plan (1983/89-1987/88). In fact so far, Iran has two plans. To distinguish them, we call the first one the Islamic plan (1983/84-1987/88) and the second one the First Five-Year Plan (1989/90-1993/94).

In Iran, as well as other oil exporting countries where the government has direct control over the disposal of a large part of national income in the form of foreign earnings from oil exports, the plan document is an important publication for analyzing government intervention in the economy and sectoral policies.

In 1983, while Iran was still suffering from the economic consequences of the embargo and its continuing war with Iraq, a revised version of the first plan (the Islamic plan) was submitted by the Iranian Parliament. The general objectives and orientations in the first plan were as follows:

1. Expansion of education and culture;
2. Securing the interests of the Mostazafan (the down-trodden people);
3. Provision of food, clothing, and housing.

The most important priorities of the plan were:

a) prevention of consumerism and emphasis on investment;

b) agriculture as the "axis" of development;

c) utilization of current spare capacity in industry and increase in productivity;

d) expansion of non-oil exports.

The plan targeted GDP to grow at an annual real rate of 8.9 percent during the plan period. The highest annual growth target belongs to the oil sector, 15.9 percent, and for agriculture the growth rate was expected to be 7.0 percent. The non-oil component of GDP is planned to increase by 6.9 percent, on average, per year. The projected share of various sectors in GDP is given in Table 3.27. As we can note, the share of agriculture remained constant between about 15 and 14 percent in the plan period. The population is projected to grow at 3.1 percent per year. Per capita GDP was projected to increase on average by 5.8 percent, while the increase for per capita non-oil GDP would be 3.9 percent per year.

Total government revenue is programmed to rise at 14.5 percent per year, and the oil share in this is expected to be 58 percent. It is projected that oil revenues rise by 14.4 percent on average, i.e. increase from \$20.3 billion in 1983/84 to \$34.8 billion in 1987/88, in 1983 constant prices. Also, the planned growth rate of 15.9 percent for the oil sector, as a financial source, was very high too, considering the low probability of a rapid expansion of the world economy, the persistent world oil glut, and the pressure on OPEC members to reduce their oil production, because of the Iran/Iraq war (Mofid, 1987).

Based on official data in the 1980s, the share of agriculture in GDP was constant, about 15 percent up to 1986, and then increased to about 23 percent for the remainder of the decade. Agricultural output from 1986 to 1989, despite the intensification of the war and the impact of drought, rose at an average annual growth rate of 4 percent. Production of food grains (wheat, rice, and barley) rose by about 5 percent during 1986-88. Although some crops were adversely affected by unfavorable weather in the latter years, rice and barley crops fared well, both recording an increase of 8 percent. Despite the limited availability of cultivable land, the area under food grain production, of which 73 percent is devoted to wheat, increased by about 2.5 percent annually. Partly due to scant rainfall in many parts of Iran in the late 1980s, the crop yields remained relatively low. While some progress has been made toward achieving increased productivity and enforced food security, results from rural-urban income expenditure surveys suggest that between 1982/83 and 1987/88 annual income (nominal) of rural families increased by 85 percent. Compared with a 62 percent increase in the income of urban families, on the other hand, the average cost of living for rural families increased by 80 percent compared with 69 percent for urban families in the same period. Income of rural families as percent of income of urban families increased from 55 percent in 1982-83 to 63 percent in 1987-88 (Central Bank of Iran, 1990).

Table 3.27. Projected share of sectors in GDP
(%)

	1983/4	1984/5	1985/6	1986/7	1987/8
Agriculture	15.3	15.1	14.8	14.5	14.2
Industry	20.3	21.6	22.9	24.4	25.9
Services	45.9	43.9	42.0	39.8	37.7
Oil	20.3	21.6	22.9	24.4	25.9

Source: Mofid, 1987.

The First Five-Year Plan, covering the period 1989/90-1993/94, was approved by the Majlis (Parliament) on January 31, 1990. Some of the macro targets of this development plan that cover the reconstruction era (following the war with Iraq and economic adjustment period) were:

1. The GDP shall have an average growth rate of 8.1 percent annually at constant 1989 prices, and per capita product shall increase by an annual rate of 4.9 percent on the average.

2. Investment shall grow by an annual rate of 11.6 percent on average;

3. Oil and gas exports shall amount to $19,200 million in 1993 and $80,090 million for the entire plan period;

4. Non-oil exports shall increase during the plan, to make possible a diversification of foreign exchange resources of the country. They shall total $17,836 million over the plan period.

Major sectoral target in agriculture were:

a) The irrigated area under cultivation of crops shall increase from 6,300,000 hectares to 6,700,000 hectares.

b) Operations aimed at improving water convergence along traditional streams over an area of 750,000 hectares, along with increasing irrigation efficiency in farms over an area of 50,000 hectares, shall be completed during the plan period.

c) Wheat production (irrigated and dry farming) shall increase by an average annual rate of 9.5 percent from 7.012 million tons in 1989 to 11.049 million tons in 1993.

d) Rice production shall increase by an average annual rate of 3.8 percent from 1,701 thousand tons to 2,055 thousand tons.

e) Red meat production shall increase by an average annual rate of 3.4 percent from 52,500 tons to 620,000 tons. Over the same period, white meat production shall increase by 11.6 percent annually. As Table 3.28 indicates, the average annual sectoral growth rates during the plan period are envisioned as follows: 5.8 percent in agriculture; 9.7 percent in oil; 14.3 percent in industry and mining; and 6.7 percent in services.

Within the agricultural sector, major increases in output are foreseen for sugar beet and sugarcane (100 percent), wheat (88 percent), oil seeds (83 percent), and feed (52 percent) over five years (see Table 3.29). Based on the most recent official reports of performance of the agricultural sector in the First Five-Year Plan (1989/90 to 1993/94), the following conclusions may be reached:

Wheat. The production of wheat which was 7,012 thousand tons in 1989/90 reached about 10,354 thousand tons in 1993, giving an annual growth rate of 10.2 percent. The annual growth rate targeted in the plan is 9.8 percent. The actual rate of growth of wheat production exceeded the planned rate.

Rice. Rice production in 1989/90 was 1,700 thousand tons and 2,500 thousand tons in 1993 giving an annual growth rate of about 10.1 percent. The projected increase in rice production in the First Five-Year Plan was 4.8 percent per year.

Sugar beets. The production of sugar beets in 1990 was about 4,446 thousand tons, and 6,000 thousand tons in 1993, an increase of 7.8 percent. This fells short compared with the projected growth rate of 9.2 percent.

In 1992, the per capita daily consumption of animal protein was about 19.9 grams, 16.8 grams of which was provided by domestic sources and 3.1 grams by outside sources (imports). The share of meat in per capita consumption of animal protein was about 59 percent, including 5.28 grams of red meat, 3.89 grams of poultry, 2.49 grams of fish, 6.48 grams of milk products, and 1.84 grams of eggs. The 19.9 grams compares favorably with other developing countries, 12.7 grams (Jihad, 1992), but not when compared with the FAO estimate of 24 grams of animal protein. It seems that Iran in the future, given a high rate of population growth, needs to improve the per capita consumption of protein to meet established levels recommended for good nutrition.

Red meat. Red meat production rose from 525 thousand tons in 1989 to 625 thousand tons in 1993. The actual growth rate of red meat production of 4.5 percent is greater than the planned growth rate of 3.4 percent.

Poultry. The production of chicken meat increased from 300 thousand tons in 1989 to 520 thousands tons in 1993, an actual growth rate of 14.7 percent. This

Table 3.28. Economic indicators in Iran

	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88	1988/89	proj. 1989/90
Rates of growth										
				(Annual percentage changes)						
Real GDP (market prices)	.....	7.9	14.4	10.3	3.3	4.2	-8.4	-1.1	1.7	4.4
Oil sector	.....	8.9	121.9	3.1	-19	1.1	-14.6	13.8	6.5	21.4
Agriculture	.....	11.0	9.7	3.5	7.3	8.0	4.3	2.6	3.9	2.7
Industry	......	15.0	-7.9	14.3	8.7	-1.6	-6.2	-5.2	-1.1	-6.1
Services	......	6.0	5.3	10.5	6.9	6.3	-10.8	-3.9	1.6	2.4
Share of total GDP										
Oil sector	9.5	9.5	18.5	17.5	13.8	13.4	12.4	14.3	14.9	17.4
Agriculture	14.8	15.1	14.5	13.8	14.4	14.9	17.0	17.6	17.9	17.7
Industry	21.4	22.6	18.3	19.2	20.3	19.2	19.6	18.7	18.1	16.4
Services	54.3	52.8	48.7	49.5	51.5	52.5	51.0	49.4	49.1	48.5

Source: Cetral Bank of Iran, 1990.

Table 3.29. Islamic Republic of Iran: Major targets of the agricultural sector under Five-Year Plan (1000 tons)

	1989/90	1993/4	Percent change
Wheat	4,500.0	8,459.0	88.0
Rice	1,701.0	2,055.0	20.8
Sugar	115.0	231.0	100.9
oil seeds	156.0	285.0	82.7
Cotton	359.7	452.0	25.7
Feed	9,819.5	14,898.0	51.7

Source: Central Bank of Iran, 1990.

is greater than the planned rate of 11.4 percent.

Eggs. The actual growth rate of egg production, matched the projected rate of 11.8 percent. Production of eggs rose from 280 thousand tons in 1990 to 390 thousand tons in 1993 (Ettela'at, 1993).

Saudi Arabia: Physical Features and Natural Resources

The Arabian Peninsula is a strongly marked geographical unit, delimited on three sides by sea--on the east by the Persian Gulf and Gulf of Oman, on the south by the Indian Ocean, and on the west by the Red Sea--while the other remaining side is mostly composed of desert. The largest state in that peninsula is Saudi Arabia, which has a land area of 2,240,000 square kilometers (865,000 square miles).

Saudi Arabia's latitude dictates that its climate is hot. There is, however, remarkable variation in the climate among the various regions of the country. The north and central regions of the country enjoy a continental climate: summers are quite hot, winters quite cool, and all season are dry. On the coasts the humidity can be high but the seasonal variations in temperature are moderate. The mountainous regions of the southwest are the only regions which receive appreciable amounts of rainfall. Because of its land-locked nature, the winds reaching Arabia are generally dry, and almost all the area is arid. The winter season precipitation falls at the following rates: 30-90 m. m. in the north, 85-110 m. m. in the central regions, and 50-70 m. m. in the east. The western hills receive a rainfall rate of 300 m. m. . In general, rainfall is very limited and lacks uniformity in distribution in terms of both time and space. In the western hills rainfall may come as intense storms, causing destructive floods.

Surface water is available in the form of quick floods, varying in flow rate and distribution (mostly found in the Asir mountains, southwest). The total surface runoff is estimate at 2.2 billion cu. m. of which 1.6 billion cu.m. run through the coastal valleys to the Red Sea. The ground water resources vary, depending on the water bearing formation. The Quaternary sedimentary rocks in the Red Sea coast and the sedimentary rocks in the region of the valleys provide a volume of 470 million cu. m of water, while the other water formations provide some 430 million cu.m. of water (Baasiri, 1990). The area of arable land is concentrated essentially in the coast strip in the Tahama plain, in the Oasis region in the east coast, and in the internal Oasis.

Based on United Nations estimate, 1987 population of Saudi Arabia for mid-1990 was 14,870,000. An estimated 67% of the population reside in urban areas in 1980, with remaining 33%, including settled farmers (clustered around Oases) and the bedouin (nomadic desert dwellers), living in rural areas. The total expatriate population in 1985 was estimated at 4,563,000. However, two factors have led to recent decline of the expatriate population to 1 million. First, the economic recession and the reduction in construction projects due to declining oil prices have reduced the demand for labor. Second, the government has vigorously attempted to restrict the number of expatriates partly due to rapid population growth rate.

Like other countries in the region, the population density of Saudi Arabia is a product of its climate. It is very low and very unevenly distributed across the country. Large chunks of the peninsula are virtually uninhabited. While there are teaming cities dispersed throughout the country, they are found disproportionately along the coasts.

Saudi Arabia is the richest, yet possibly the most enigmatic country in the Middle East because of much publicity owing to its crucial role in the world supply of petroleum. Little is known about other economic resources in Saudi Arabia. In fact, it has only been fairly recently that non-oil minerals have attracted much attention. For example, gold is now commercial mined. In 1991, 31 sites out of 495 in the country were estimated to contain more than 1000 kg. each of gold.

Saudi Arabia is the biggest oil producer within Organization of Petroleum Exporting Countries (OPEC), claiming 27% of OPEC's output in 1990, and is the third biggest producer in the world, with about 10.3% of world output in 1990. Saudi Arabia proven reserves of petroleum were officially declared to be 255,000 million barrels in January 1990, allowing 133 more years of production at 1989 levels of extraction (MENA, 1992).

Agricultural Development

The first Saudi Arabian budget deficit in decades took place in 1984. As the leading oil producer in OPEC, Saudi Arabia suffered from declining oil prices. Oil export earnings fell from 76 billion dollars in 1982 to about 43 billion dollars in 1983. At the same time, agriculture showed some growth, creating more jobs than the construction sector. Efforts to reduce dependency on oil revenues were intensified and new projects in certain industries were persuaded. For example, fertilizer exports reached 2 million tons in 1983. In response to a procurement price of $28 bushel for wheat, output of wheat doubled to almost 700,000 tons in 1983. This response made Saudi Arabia self-sufficient in wheat in 1984, but it crowded out expansion of feed grains and some vegetables. The cereals production increased from 489,000 tons in 1982 to 1,444,000 tons in 1984.

The oil revenues in 1984 and 1985 decreased to $24 billion and $17 billion, respectively from $34billion in 1983. Saudi agricultural production increased 21 percent in 1985, compared with 31 percent in 1984. Livestock production had an upward trend in 1980s. Meat production, for example, increased from 218,000 tons in 1982 to 402,000 tons in 1985. This improvement in agricultural production is largely attributed to massive investment in agriculture (e.g., irrigation system, marketing facilities) made in earlier periods. In 1986, Saudi Arabia experienced its worst balance of payment deficit as export earnings declined by 25 percent to $17 billion. Despite revenue shortfalls, elaborate subsidies for agriculture and consumers remained unchange. Saudi polices curtailing wheat production, such as decreasing producer price of wheat from $1,000 per ton to $570, slowed the rate of overall agricultural growth in 1986. Agricultural production increased 11% compared with 21% in 1985. Wheat production in 1986 grew by 10%, while it doubled in 1982, 1983, and 1984. However, surplus of wheat made the country a net exporter in wheat after 1984. For example, wheat production in 1985 was about 2.14 million tons, while the wheat consumption was 1.3 million tons (International Wheat Council, 1992). The FAO index of overall agricultural production in Saudi Arabia had a upward trend in 1986-1991 period on both an aggregate and a per capita basis. The cereals increased on average by 43.7 percent annually between 1980 and 1987, while the meat production grew at 19.2 percent per year during the same period. Therefore, the grains self-sufficiency rate increased from 12 percent in 1983 to 26 percent in 1987.

As will be discussed in the next section, Saudi Arabia's agricultural goal in the 1980s, was to reduce import dependency in almost all foodstuffs. The Government of Saudi Arabia used several instruments to achieve its agricultural objectives. These included large investment in irrigation projects (for example, irrigated land increased from 555,000 hectares in 1980 to 900,000 hectares in 1990), land reclamation, land redistribution, price supports, and a system of comprehensive inputs and credit subsidies (annually $3 billion, on average) (Developing Economics, USDA, 1990).

Saudi Arabia was one of the leading world importer's of agricultural products, particularly of feed grains, in the 1970s and 1980s. Imports of agricultural products expanded rapidly in 1970s but contracted in 1980s as oil revenues sagged and domestic farm output expanded. Major agricultural imports were coarse grains rice, fruits and vegetables, live animals, meats, and dairy products (see Table 3.30).

The geography, climate, and topography of Saudi Arabia have perhaps their greatest impact on the country's agriculture. However, the past two decades witnessed monumental changes in the location and the nature of Saudi Arabia's agricultural sector. In 1970, this sector employed some 70 percent of the country's population, primarily in the manner of farming that had been practiced for generations. By 1980, the fraction had fallen to 60 percent. In 1990, agriculture contributed only about 8 percent of gross domestic product (GDP), although the sector employed an estimated 40 percent of total population. Its contribution to GDP increased from 3.3 percent in 1984, mainly as the result of the decline in oil revenues from beginning in the mid-1980s. In 1988 agricultural exports accounted for about 40% of non-oil exports. On the other hand, agricultural imports as a percentage of total imports increased from 13 percent in 1980 to 19 percent in 1990 (again, see Table 3.17).

Table 3.30. Saudi Arabia: Agricultural trade summary

Commodity	Total imports 1969-71	1979-81	1986-88	Growth rates 1970's	1980's
	$ million			percent	
All merchandise	757.5	29967.7	20336.8	44.5	-5.4
Ag. products	223.5	4121.4	3667.2	33.8	-1.7
Live animals	25.2	388.4	416.6	31.4	1.0
Meat & prep.	6.2	428.8	325.8	52.8	-3.8
Dairy prod. & eggs	20.6	341.2	370.4	32.4	1.2
Wheat & flour	13.8	224.6	45.0	32.2	-20.5
Coarse grains	5.2	554.9	643.7	59.7	2.1
Edible oils	4.0	129.9	77.3	41.5	-7.1

Source: FAO and UN data.

Agriculture Sector in the Development Plans

Historically, the sector has received scant attention from authorities due to their belief that Saudi Arabia's comparative advantage was not in agriculture and relatively cheap food could always be bought from the world's surplus countries with export revenue from its highly valued hydrocarbon exports. Some events in 1979 such as the emerging world-wide food shortage, the emergence of veiled threats of a food embargo by many supplying countries (presumably to counter oil price increases), and the realization that industrialization in the Kingdom would not be adequate to provide sufficient jobs to employ a rapidly growing Saudi work force made the policy makers pay more attention to the agricultural sector in their second (1975-80) and especially third development plan (1980-85). Along with the increased investment and use of new technology in agriculture, three other factors have dramatically affected Saudi Arabian agriculture. First, consumption patterns have changed partly because more consumers are expatriates and partly because the huge jump in incomes has resulted in significant changes in consumption patterns. The second factor is that cities attract many workers from farming. This attraction stems in a large part from the relatively high-paying jobs that are available in the urban areas, but also from the availability of superior services, such as education and health care in the cities. Finally, the cities themselves are encroaching on agricultural lands. Riyadh and Al-Medinah are two cases in point. In both cases, development of the city involves destruction of parts of the oasis that were the basis for traditional sedentary agriculture. The determination of objectives and designation of the most effective methods of achieving them are the core of a development plan. And the success of planning depends on the comprehensiveness and consistency of these objectives and the invariability of means such as producer price policy. We will highlight the agricultural policies of each development plan and briefly describe their achievements through agricultural policies.

First plan (1970-75)

The objectives of the agricultural sector plan were as follows:

1. Improvement in efficiency and increase in output for agricultural products.
2. Increased productivity and utilization of resources for the welfare of present and future generations.

The plan was very modest in size, that is, only about SR 80 billion (Saudi Riyal, since 1986 the official rate has been fixed at US$1=3.745 riyals) was invested, mainly for infrastructure and public utilities, and about SR 33 billion of which was invested in economic and social development. Consequently, agricultural production grew slowly in that period. Subsidization of agriculture under this plan went to supplement research and extension programs. The growth of value added in the agriculture sector under the first plan was about 3.6 compared with a target of 4.6 percent. However, after the first oil shock in 1973/4, the Government found itself in possession of vast financial resources and determined to embark on a massive program of industrialization and modernization.

Second plan (1975-1980)

The objectives of the agricultural sector can be summarized as follows:

1. Raise per capita income and improve the welfare of rural people.
2. Minimize the country's dependence on imported food.
3. Release surplus agricultural labor for employment in other sectors.

As a direct result of the first shock in oil price, the government expenditure increased almost nine-fold over the first plan, reaching SR 700 billion. As mentioned earlier, by using capital intensive techniques, the agricultural sector released about 96,000 persons. However, the sector still remained the largest employer with about 40 percent of the labor force. Due to huge investments and support in the agricultural sector, irrigated land increased by 16 percent and production grew by 5 percent. Despite the pessimism of the most foreign commentators, the Saudis pursued the goals of the Second Plan with great determination, and the results have been, on the whole, successful. The infrastructure grew remarkably, endowing country with the basic transport and communications facilities required by a modern developed state (MENA, 1981/82). By the end of the second plan, Saudi Arabia was almost 90 percent self-sufficient in vegetables, 70 percent in fresh milk, and 27 percent in wheat.

Third plan (1980-85)

The agricultural objectives in this development plan were as follows:

1. Establish and maintain self-sufficiency in food production, while recognizing both producer and consumer interest.
2. Provide opportunities for attaining reasonable agricultural incomes and raise the welfare of rural people.
3. Optimize the use of land and agricultural water sources.
4. Improve the skill level in the agricultural sector and protect the agricultural environment.

Due to the victory of the Islamic revolution in Iran, the price of oil jumped up (second oil shock) enabling Saudi Arabia to embark on an ambitious investment plan, about SR 783 billion (about $325,000 million) in the third plan. This total investment did not include defense spending, which was the largest item of expenditure under the previous plan. By improving the agricultural support system, such as easy agricultural credit, agriculture's contribution to the GDP grew at 8.7 percent annually, in comparison to its target growth of 5.4 percent. The third Five-Year Plan (1980-85) was intended to shift the emphasis from infrastructure projects to productive sectors, with particular importance accorded to agriculture with the aim of achieving "food security" by being less dependent on imported foodstuffs (MENA,1992). Hence, the most significant production achievement in that plan was a nine fold increase in wheat production that made the country self-sufficient in wheat in 1984.

Fourth plan (1985-90)

The objectives of the agricultural policies in this plan can be summarized as:

1. Achieve broad-based improvement in the welfare of the rural population.
2. Improve the efficiency of agricultural production and marketing and attract private capital investment into agriculture through the provision of loans with easy terms.

The fourth plan envisaged a total expenditure of SR 1,000,000 million at current prices, SR 500,000 million of which were allocated to development projects in the civilian sector. By mid-1988, the fourth Development Plan was widely considered to have fallen short of its targets mainly as a result of the steep decline in oil revenues following the sharp decline in oil price in 1986. The implementation of many projects, in particular those involving public utilities, had been delayed. It was estimated that the agricultural sector output growth in real terms was 6 percent, which is lower than the 8.7 percent experienced in the third plan. The fourth plan emphasized diversification of the economy from a nonrenewable source, oil, to a renewable sector, agriculture. The plan is expected to rase of the rural standard of living, giving a positive influence on the rural-urban population balance and food security in general.

Fifth plan (1990-1995)

This plan emphasized expansion of the private sector and manpower. Two-thirds of the SR 753 billion ($200.8) planned expenditures are allocated to civilian use fifteen percent or SR 73 ($19.46 billion) of this is directed to economic resources development, which partly covers spending by the Ministry of Agriculture and Water. The major objectives of this plan are as follows:

1. Expanding government revenues for the purpose of increasing non-oil revenues.
2. Insuring economic stability and maintaining it through stable government expenditure.
3. Increasing the dependency of the national economy on business-sector activities.
4. Increasing the emphasis on achieving balanced development among the country's regions.

Agricultural GDP grew by 13.88 percent in total over the 1980-90 period, and is targeted to grow by 7 percent during 1990-95 (The Middle East Review, 1992). The rapid growth of agricultural output, as a main goal to achieve food security in Saudi Arabia is mainly the result of the application of intensive modern methods of cultivation and irrigation. Since scientists express doubts about the capacity of the Kingdom's ecology to support this kind of intensive production, such as center-pivot irrigation, the 1990-95 plan promises intensive study of water resources, with completion of a National Water Plan (abandoned in 1983).

Strategies and tactics: subsidies and support

The support for agriculture starting in early 1970s began at the level of research and development. At the other end of the production process the government purchased many farm products at prices which are well above the world market price. The government's program of incentive consists of three parts: subsidized purchase of machinery and equipment; provision of imports such as electricity, fertilizer and seeds below cost; and direct output subsidies, typically in the form of price floors.

However, increasing oil price in 1973/4 allowed the government to design a 20-year long-range agricultural policy, which is laid out in the Second Plan(1975-80), under "National Agricultural Policy" with three aims: (1) "Develop strategic self-sufficiency in important food and fiber commodities and develop price, import and production programs to further such self-sufficiency," (2) "Establish the means by which farmers are encouraged and allowed to remain in farming,....;" and (3) "Encourage agricultural production and agribusiness." Subsidies, in all forms mentioned above, were the tools to achieve these goals. The Agricultural Bank provided subsidies valued at SR 321 million in 1983. This represented a 35 percent increase over the previous year. The provision of engines and pumps accounted for over 35 percent of this total, with subsidies for animal feed purchases accounting for another 33 percent and another 28 percent for agricultural machinery. The remainder was allocated to the financing of poultry and dairy farm equipment and to transportation cost for importing cattle (SAMA Annual Report, 1403 (1983) pp. 87-8).

By far the most important price support program involves wheat. The hugely expensive wheat growing policy has in some respects been too successful. The self-sufficiency target was surpassed for the first time in 1984 and there have been massive surpluses ever since. Not only does the kingdom now grow more than twice as much wheat as it can consume, it also suffers from a critical shortage of silo storage space.

Directly resulting from generous state subsidies, wheat production has risen from 3,297 tones in 1978 to 1.3 million tones in 1984, and about 2 million tones a year in 1985 and 1986. Domestic consumption is about 800,000 tones a year. The water-intensive, center-pivot irrigation systems favored by Saudi farms, whereby a large circle of land is watered by a continually revolving sprinkler, has aided the success. Even in the fourth plan (1985-90) the Government subsidies continued. For example, 9,209 interest free loans valued at SR155 million was distributed by the Agricultural Bank in 1985/6. Also, chemical fertilizers, domestic or imported, were distributed at half-price, and the government paid about 45% of total cost of farm machinery purchased by local farmers.

Petroleum earnings and agriculture

In 1986, Saudi Arabia experienced its worst balance of payments deficit as export earnings declined by a fourth to $21 billion and imports remained at $29 billion. Only six years previously (in 1980) the country had a $78 billion trade surplus. Gains from industry services and agriculture were not sufficient to offset losses in petroleum revenues, and the country's GNP declined by a fourth to about $73 billion—about half that of 1982. Despite revenue shortfalls, elaborate subsidies for agriculture and consumers remained. However, efforts to maintain a relatively normal business environment and the usual subsidies resulted in a $13.5 billion budget deficit.

Subsidies for feed and facilities contributed to a striking rise in poultry meat output from 82,000 tones in 1982 to an estimated 305,000 tones in 1986. Demand for poultry meat increased more rapidly than forecasted, causing large imports to continue despite expansion in the domestic output. In 1986, egg output was 210,000 tones and imports of some hatching eggs continued.

The trend of a lower petroleum revenue continued in 1986 as world prices declined. However, continued use of investment income to diversify development and temper the private sector slowdown is expected. Efforts are being made to diversify investments and reduce dependence on petroleum exports.

The procurement price of $85.50 per ton of barley is considered too low an incentive to shift 100,000 hectares of wheat to barley, although such a move would eliminate the wheat surplus and make a small dent in massive barley imports. The 50 percent feed subsidy and auxiliary subsidies for feedlot operators are under review as part of an effort to reduce the budget deficit.

In spite of budget deficits, Saudi food imports remained high for several reasons. As a conservative monarchy—surrounded by instability in a volatile region of the world—the Saudis make domestic political stability a high priority of the government, and elaborate consumer subsidies are a primary mechanism to distribute the national income derived almost totally from petroleum. These consumer benefits include large direct subsidies on many basic foodstuffs.

Furthermore, about 70 percent of the Saudi labor force is composed of foreign workers whose wages are many times higher than those in their homelands. Food subsidies are available to them, and their consumption levels are high (recently the tract of replacement of unskilled workers from Asia by skilled workers of Japan increased). In fact, per capita consumption of higher valued food, such as meat and dairy products, is increasing rapidly. Finally, another reason is competition among crops for limited land base has led to production decline in sorghum, barley, and millet, while as mentioned before, wheat output has expanded(see chapter V for more detail).

Based on several factors, such as $15 billion annual interest income from previous investment of surplus income, Saudi Arabia will probably continue agricultural imports at the recent trend, to maintain present consumption levels and to ensure the domestic political stability inherent in consumer prosperity. Note that expenditures of imported food have changed very little since their 1982 peak of $5.2 billion.

In contrast to the above analysis, Tunday and U. Yanas (1983) several years ago have said: "At the present and for the foreseeable future, Saudi Arabia's oil wealth provides the necessary hard currency to finance imports of food. However, it should not be forgotten that there is a "window of time" for Saudi Arabia for diversifying its revenue base which at the present time comes from the export of one depleting source, crude oil. Developing a modern and effective agricultural sector to usher Saudi Arabia towards self-sufficiency in food is one avenue open to the government planners. However, the real challenge facing Saudi Arabia is to arrive at this development objective long before the "window in time" closes. They believe rapid expansion of the agricultural sector along the lines achieved in the third planning period is a luxury that even the Saudi Arabia will be unlikely to be able to continue to afford.

Agricultural policies and food security

Food security has been a major goal of the Saudi government since the beginning of its agricultural development process in the mid 1970s. As mentioned earlier, the government supported the agricultural sector by giving direct or indirect subsidies, which included the following:

(a) Free land to farmers and agricultural companies, up to 400 hectares per investor.

(b) Interest-free and easy-term loans (in 1990, the total value of loans was SR 854 million).

(c) Substantial support, including guaranteed producer prices, for major crops such as wheat and barley and dates; these supports have been a major factor in boosting domestic agriculture, etc. (Foreign Agriculture, 1991). In spite of the marked increases, agricultural production has not kept pace with overall food demands. In addition, the food sector is dependent upon imports of some items, such as seeds, and its increased dependency on feed product such as barley made Saudi a leader of importing feed grains in the world. The government has constantly stressed attainment of greater food security as the main justification for its agricultural policies—the third plan called for "a prudent level of self-sufficiency in food production" and recently the Minister of Agriculture declared "to produce your own food on your own land, it is a matter of security". Clearly, less reliance on food imports is considered synonymous with greater food security. The apparent success in reaching more self-sufficiency in certain food items, achieved at such tremendous costs, has not materially increased food security (Nowshirvani, 1987). But Saudi officials have a very different view of their wheat policy, one that is reasonable for the most part (Near East, South Asia, 1986):

1. Wheat is a strategic commodity just like oil, but more important. Saudi Arabia, as well as other exporting countries, has been threatened by the United States with possible embargoes on wheat, if an oil embargo is imposed.
2. The price of wheat has increased in recent years to between $200 and $117 per ton, creating uncertainty about the volume of foreign exchange required to import the kingdom's requirements.
3. Saudi programs achieved self-sufficiency in wheat and expanded to cultivated areas in the countryside job opportunities and good utilization of resources. In addition to saving at least $300 million a year from reducing wheat imports, and using this amount for wheat consumers, as subsidy prices, and paid to producer when cultivated, in riyals, not dollars.
4. If Saudi Arabia did not encourage agriculture in general and wheat in particular, it would have to create tens of thousands of job opportunities for those now working in agriculture. If they emigrate to cities, they would increase the burden on the government's already rising deficit and force billions of riyals to be spent on expanding urban facilities.

CHAPTER IV. EMPIRICAL INVESTIGATION

Methodology and Model

The review of literature in Chapter II described the conribution of earlier studies and common focus and method. The use of a single estimate of the covariability of variables impacting food security, such as coefficient variation (cv), which does not have great prediction power and generally explains only a small proportion of variation in variables hides some useful information. This approach fails to account for some persistent residual variability that might not be due to the initial shock in the variables but rather to the dynamic adjustments that ensure in the economy as it moves toward some new equilibrium point after the initial shock. Capturing this rich dynamic adjustments is one of the strengths of the Vector Autoregression (VAR) methodology employed in this study. The model--a dynamic simultaneous equation model--in the VAR representation can capture the rich causal relationships in the most important variables impacting food security. Whereas earlier studies impose a priori exogenity classification of variables thereby closing any exploration of dynamic feedback interactions, the VAR is primarily intended to capture this interactions. What follows is a detailed description of the methodology used in this study, highlighting its appropriateries and contribution to the study of food security.

In the absence of a theoretical consensus regarding causal relationship, any attempt to explore and evaluate oil price impact on food security variables must employ an empirical method most appropriate for making causal inferences. It is universally recognized that the results of standard econometric analysis (e.g., correlation and regression) are not adequate in and of themselves to permit the drawing of causal inference (Kinsella, 1990). Since data can speak only through models, it seems a vector autoregression (VAR) that makes minimal theoretical demands on the structure of a model is appropriate for this purpose. On the other hand, since theory building is a multistage process, in the second stage, i.e., after identification, those tenets are translated into equation. Imposing fewer and weaker restrictions may be a more advisable using the VAR approach in the study of food security. VAR focuses on the causal relationships implied by the estimated reduced form of what is essentially an unknown structural model and on certain of that model's dynamic properties (Freeman et al., 1989).

In Chapter V, we explain the causality concept and other relevant issues. Here we briefly explain the causality definition. Granger (1969) proposed an operational definition of causality: Y_{t-i} is caused by X_{t-j} if Y_{t-i} can be better predicted using all information than if the information apart from X_{t-j} is used ($j \geq i$). The most common method of applying causality is VAR, based largely on the work of Sims (1980), where the joint behavior of a vector and variables of interest is examined by regressing each variable on the lags of all variables in the system, including itself. Let us consider a bivariate first-order VAR model, where the longest lag length is one, for illustrating the causality relationships and dynamic properties between variables:

$$X_t = \alpha_{10} - \alpha_{12} Y_t + \beta_{11} X_{t-1} + \beta_{12} Y_{t-1} + \epsilon_{1t} \qquad (4.1)$$

$$Y_i = \alpha_{20} - \alpha_{21} X_t + \beta_{21} X_{t-1} + \beta_{22} Y_{t-1} + \epsilon_{2t} \qquad (4.2)$$

where it is assumed: (i) X_t and Y_t are stationary processes, that is, their mean, variance, and covariance are invariant with respect to time; (ii) error terms, ϵ_{1t} and ϵ_{2t} are white noise processes with standard deviation σ_1 and σ_2; and (iii) ϵ_{1t} is uncorrelated with ϵ_{2t} for all leads and lags. The structure of this model can present the lagged and contemporaneous effects of one variable on the other variables. For example, $-\alpha_{12}$ is the contemporaneous effect of a unit change in Y_t on X_t and β_{12} is the lagged (past) effect of a unit change in Y_t on X_t. In VAR terminology, the error terms ϵ_{1t} and ϵ_{2t} are innovations (or shocks) in X_t and Y_t, respectively.

To show the Granger causality condition more clearly, let us assume $\alpha_{10} = \alpha_{20} = 0$ and focus just on the first equation, 4.1. Based on Granger's causality definition if we assume all information apart from Y_t and Y_{t-1} is presented by X_{t-1} then the hypothesis "Y Granger causes X" implies either that α_{12} or β_{12} is nonzero. Similarly, for the second equation, 4.2, "X Granger causes Y" if either α_{21} or β_{21} is nonzero. Equations 4.1 and 4.2 are not in reduced form since both X_t and Y_t have contemporaneous effects on each other. In practice, to fit that VAR model with ordinary least squares (OLS) techniques we rewrite the model in reduced form as

$$\begin{bmatrix} X_t \\ Y_t \end{bmatrix} = (1 - \alpha_{12}\alpha_{21})^{-1} \left(\begin{bmatrix} \beta_{11} - \alpha_{12}\beta_{21} & \beta_{12} - \alpha_{12}\beta_{22} \\ \beta_{21} - \beta_{11}\alpha_{21} & \beta_{22} - \beta_{12}\alpha_{21} \end{bmatrix} \begin{bmatrix} X_{t-1} \\ Y_{t-1} \end{bmatrix} + \begin{bmatrix} 1 & -\alpha_{12} \\ -\alpha_{21} & 1 \end{bmatrix} \begin{bmatrix} \epsilon_{1t} \\ \epsilon_{2t} \end{bmatrix} \right)$$

Which can be simplified as:

$$\begin{bmatrix} X_t \\ Y_t \end{bmatrix} = \begin{bmatrix} \pi_{11} & \pi_{12} \\ \pi_{21} & \pi_{22} \end{bmatrix} \begin{bmatrix} X_{t-1} \\ Y_{t-1} \end{bmatrix} + \begin{bmatrix} \mu_{1t} \\ \mu_{2t} \end{bmatrix} \qquad \begin{matrix} (4.3) \\ (4.4) \end{matrix}$$

where μ_{1t} and μ_{2t} are serially uncorrelated, but might be contemporaneously correlated.

As mentioned by Kinsella, some of the difficulties associated with this Granger causality concept have been pointed out by Jacobs et al. (1979) and Cooley and LeRoy (1985), among others. Consider the hypothesis "Y Granger causes X" is rejected if $\pi_{12} = 0$ in the reduced form model. This implies $\beta_{12} = \alpha_{12}\beta_{22}$ which is possible even if α_{12} and β_{12} are not zero. In addition, as long as β_{22} is zero it does not need α_{12} to be zero. When π_{12} is not zero, we can not be sure whether it is current or lagged Y_t (or both) that is causing X_t.

By observing the correlation between estimates of error terms μ_{1t} and μ_{2t}, we get an indication of presence or absence of instantaneous causality. For purposes of this study only the (i) Impulse Responses Function (IRF) and (ii) Forecast Error Variance Decomposition (FEVD) are applied to measure the dynamic interactions among the variables in the system.

Identification

Given appropriate lag length and choosing the relevant variables, due to feedback inherent in the prime model (4.1) and (4.2) and correlated error terms, ϵ_{1t} and ϵ_{2t} with y_t and X_t, respectively, one cannot use OLS to estimate the parameters in that model. One can apply the OLS method to be reduced form since there are no contemporaneous variables in the right-hand-side and all equations have the same regressors. In other words, based on the correlation of error terms in both models and identification problems, one cannot recover all information presented in (4.1) and (4.2) by the reduced form model.

To clarify, compare the number of parameters of the structural model (4.1) and (4.2) with the number of parameters in (4.3) and (4.4). In the latter model, we estimate four coefficients and calculate values of var (μ_{1t}) and var (μ_{2t}) and Cov (μ_{1t}, μ_{2t}). However, the primitive system (4.1) and (4.2) contains eight parameters (four autoregressive coefficient (ß's), the two feedback coefficients (α's), and two standard deviations σ_x and σ_y). Since the number of parameters in the structural form, is greater than the number of parameters in the reduced form, by imposing one restriction in structural model (4.1) and (4.2) we will have an exactly identified or simply a identified system. In the spirit of Sims (1980) recursive model, we impose a restriction on (4.1). For example, if we believe a prior that X_t has no contemporaneous effect on Y_t, then $\alpha_{21} = 0$ in that model and rewrite restricted (4.1) and (4.2), again without intercepts, as:

$$X_t = -\alpha_{12} Y_t + \beta_{11} X_{t-1} + \beta_{12} Y_{t-1} + \epsilon_{1t} \qquad (4.1)'$$

$$Y_t = +\beta_{21} X_{t-1} + \beta_{22} Y_{t-1} + \epsilon_{1t} \qquad (4.2)'$$

and in reduced form:

$$\begin{bmatrix} X_t \\ Y_t \end{bmatrix} = \begin{bmatrix} \beta_{11} - \alpha_{12}\beta_{21} & \beta_{12} - \alpha_{12}\beta_{22} \\ \beta_{21} & \beta_{22} \end{bmatrix} \begin{bmatrix} X_{t-1} \\ Y_{t-1} \end{bmatrix} + \begin{bmatrix} \epsilon_{1t} - \alpha_{12}\epsilon_{2t} \\ \epsilon_{2t} \end{bmatrix} \qquad \begin{matrix} (4.3)' \\ (4.4)' \end{matrix}$$

By identifying the parameter in (4.1)' and (4.1)' with (4.3)' and (4.4)', now we will have a system of equations:

$$\pi_{11} = \beta_{11} - \alpha_{12}\beta_{21}$$
$$\pi_{12} = \beta_{12} - \alpha_{12}\beta_{22}$$
$$\pi_{21} = \beta_{21}$$
$$\pi_{22} = \beta_{22}$$

and by using the relationships between error terms (shocks), that is,

$$\mu_{1t} = \epsilon_{1t} - \alpha_{12}\epsilon_{2t}$$
$$\mu_{2t} = \epsilon_{2t}$$

we can calculate the three distinction elements of variance/covariance matrix of error terms, Σ, as:

$$var\ (\mu_{1t}) = (\sigma_x^2 + \alpha_{12}^2 \sigma_y^2)$$
$$var\ (\mu_{2t}) = \sigma_y^2$$
$$cov\ (\mu_{1t}, \mu_{2t}) = E(\mu_{1t}\mu_{2t}) = E([(\epsilon_{1t} - \alpha_{12}\epsilon_{2t})\ (\varepsilon_{2t})]) = -\alpha_{12}E\epsilon_{2t}^2 = -\alpha_{12}\sigma_y^2$$

Now, we have seven parameters in left-hand-side of equations that can be used to solve for α's and ß's. Decomposing the observed values of μ_t in terms of ϵ_t based on imposing restrictions on the model is called Choleski decomposition. It is one method for identifying the system.

The properties of data

The validity of the VAR representation in the above model in both forms, structural and reduced, rests on the particular stationarity property of time series X_t and Y_t. There are three possible cases, namely:

(1) X_t and Y_t are stationary. In this case the VAR model in levels is appropriate, if there is not a linear combination between them that is stationary, i.e., they are not co-integrated,

(2) X_t and Y_t are nonstationary but differencing makes them stationary. A first differenced version of the model is appropriate for this case.

(3) X_t and Y_t are nonstationary, but they are co-integrated. Then the appropriate model is an error-correction model (ECM).

The economic time series is a collection of economic data observed periodically with equal time intervals, and by their nature they are stochastic processes. In other words, we assume that each value X_1, X_2....X_T in the series is drawn by random from a probability distribution. When we begin to develop models for these time series, we should know if the underlying stochastic process that generated them can be assumed to be invariant over time. A stochastic process, X_t, is called covariance stationary or just stationary if the characteristics of the process do not change with respect to time or if it satisfies the following conditions:

1. The expected value (mean) of X_t is constant for all t and k

$$E(X_t) = E(X_{t+K}) = \mu_x$$

2. The variance of X_t is constant for all t and k.

$$E\left[(X_t - \mu_x)^2\right] = E\left[(X_{t+k} - \mu_x)^2\right] = \sigma_x^2$$

3. At two time points, the covariance is constant and only depends on the time interval

$$E\left[(X_t - \mu_x)(X_{t-k} - \mu)\right] = E\left[(X_{t+k} - \mu_x)(X_{t+k+m} - \mu_x)\right] = \gamma_m$$

If the stochastic process X_t is stationary, then we can model the process via an equation with fixed coefficients that can be estimated from past data and use that model for explanation and forecasting. Nelson and Plosser (1982) were unable to reject the hypothesis of "nonstationary" (single unit root test) in the autoregressive representation of a wide variety of macroeconomic time series (Rudehusch, 1992). Therefore, one would suspect that many of the time series that one encounters in economics are not generated by stationary processes. Fortunately, many of the nonstationary processes have the desirable property that if they are differenced one or more times, the result is a stationary process. The number of differencings that are necessary is called the "order" of integration ($X \sim I(d)$). Nelson and Plosser (1982) also show the distinction of time trend and difference Stationary Process (SP). These two types of non-stationarity can have important implications for many questions in macroeconomics. For example, a shock in a Trend Stationary Process (TSP) has no long-lived effects while a shock to a Difference Stationary Process (DSP) has persistent effects. To show how these effects work, consider two simple processes as examples for the TSP and DSP processes:

$$X_t = \alpha_0 + \alpha_1 t + \mu_t \quad (TSP)$$

$$X_t = \rho X_{t-1} + \epsilon_t \quad (DSP,\ if\ \ \rho = 1)$$

If we assume $\rho = 1$, i.e., unit root, this process is called a random walk, with $E(\epsilon_t) = 0$ and $E(\epsilon_t\ \epsilon_s) = 0$ for $t \neq s$. As a classical example of nonstationary process after first-differencing, consider the random walk process transformed to a stationary process:

$$\Delta X_t = X_t - X_{t-1} = \epsilon_t$$

Since the ϵ_t are assumed independent over time, it is clearly a stationary process.

Let us consider a process containing both (TSP) and (DSP) components such that

$$Z_t = \alpha + \beta t + \rho Z_{t-1} + \epsilon_t$$

where ϵ_t is white noise and ρ is assumed to be $o < \rho < 1$. If there is an ϵ_{tl} shock at time T,

$$\begin{cases} \epsilon_t = \epsilon_T\ if\ \ t = T \\ \epsilon_t = 0\ \ otherwise \end{cases}$$

The solution of this first-order difference equation,

$$Z_t = \frac{1}{1-\rho}(\alpha + \beta t) + \sum_{i=0}^{\infty} \rho^i \epsilon_{t-i} \cdot \cdot$$

We can write the solution for the (TSP) case as:

$$Z_{T-1} = \frac{1}{1-\rho}(\alpha + \beta(T-1))$$
$$Z_T = \frac{1}{1-\rho}(\alpha + \beta T) + \varepsilon T$$
$$Z_{T+1} = \frac{1}{1-\rho}(\alpha + \beta(T+1)) + \rho\varepsilon_T$$
$$\vdots \qquad \vdots \qquad \vdots \qquad \vdots$$
$$Z_{T+s} = \frac{1}{1-\rho}(\alpha + \beta(T+s)) + \rho^s\varepsilon_T$$

Therefore:

$$\frac{\partial Z_{T+s}}{\partial \epsilon_T} = \rho^s$$

Since $0 < \rho < 1$, if s approaches infinity, then ρ^s approaches zero.

Cointegration and error correction models

The idea of cointegration is that if, in the long run, two or more series move closely together, even though the series themselves are trended, or in more generally are not stationary, a linear combination between them is stationary. In the cointegration literature all that is meant by long-run or equilibrium relationships is that it is an observed relationship which has, on the average, been maintained by a set of variables for a long period. Formally, we can define cointegration as: The components of the vector Z_t, $Z_t = (X_t, Y_t)$, say, are said to be cointegrated of order d, b [denoted $Z_t \sim CI(d,b)$] if:

(i) all components of Z_t are I(d); e.g., $X_t \sim I(1)$ and $Y_t \sim I(1)$, i.e., both are nonstationary;

(ii) and, there exists a vector $\alpha(\neq 0)$ such that $\epsilon_t = \alpha' Z_t \sim (d\text{-}b)$, b > e.g.,

$\epsilon_t = [Y_t - \beta X_t]$, then $\epsilon_t \sim I(d\text{-}b)$. Thus, if two or more variables yields a linear combination that has a lower order of integration the vector α,[1,-ß], (or any multiple of it) is a "cointegrating vector." In the bivariate case, the order of integration, d, should be the same in two variables. Otherwise, one would expect the "error" (Y_t-ßX_t) between them to become infinitely large over time. To clarify the error correction, suppose that X_t and Y_t are random walk process, I(1), but a linear combination of them, ϵ_t, is I(0). Then an equation in first differences is of the form

$$\Delta Y_t = a \Delta X_t + \alpha(Y_t - \beta X_t) + V_t \tag{4.5}$$

Since ΔY_t, ΔY_t, (Y-ßX_t), and V_t are all I(0), stationary, this is a valid equation. We can distinguish between a long-run relationship between Y_t and X_t, that is the manner in which the two variables drift upward together, and the short-run dynamics, that is the relationship between deviations of X_t and Y_t from their long-run trend (Greene, 1993). Equation 4.5 captures both the long-run and short-run relationship between Y_t and X_t. The "error", (ϵ_t,), in this equation is called equilibrium error. When X_t and Y_t are cointegrated, the short-run dynamic process through which the series adjust toward their long-run equilibrium are presented by constrained Error-Correction-Model (ECM's). The ECM's specify that the first differences of Y_t and X_t are functions of distributed lags of first differences of both variables as well as the once lagged equilibrium error, ϵ_t, referred to as the "error-correction" term (Denbaly and Torgerson, 1992). By the definition of cointegration, since two series are cointegrated, the error-correction is stationary and matching the

I(0) first differences. In the bivariate case, such as our model for illustration, the cointegration vector, [1,- ß], must be unique since any other parameters, say (2 ß + c), introduces the additional nonstationary term, c X_t. When more than two variables are involved, the cointegration vector(s) may not be unique. Engle and Granger suggest estimating, ß in the long-run equation by ordinary least squares (OLS) and substituting it in the short-run equation to estimate the other coefficients, i.e., the speed of adjustment, X, and the coefficient of ΔX_t. This two-step procedure assumes a unique cointegration-vector, so one could not distinguish between the existence of one or more cointegrating vectors. Johansen and Juselius (1990) provide a maximum likelihood method to estimate the parameters and explore the number of cointegrating vectors. If we assume in our bivariate AR (1) model of X_t and Y_t that there is one cointegrating vector, the ECM may be expressed as :

$$\Delta X_t = \alpha_{10} + \sum_{j=1}^{n} \beta_{11j} \Delta X_{t-j} + \sum_{j=1}^{n} \beta_{12j} \Delta Y_{t-j} - \alpha_1 [X_{t-1} - \beta Y_{t-1}] + \mu_{1t} \tag{4.6}$$

$$\Delta Y_t = \alpha_{20} + \sum_{j=1}^{n} \beta_{21j} \Delta X_{t-j} + \sum_{j=1}^{n} \beta_{22j} \Delta y_{t-j} - \alpha_1 [X_{t-1} - \beta Y_{t-1}] + \mu_{2t} \tag{4.7}$$

Equation (4.6) and (4.7) are ECM representation of the dynamic system in primitive system, (1), because, for example, the evolution of Y_t over time is explained by its own past changes (i.e., lag of the first difference ΔY_t) and an adjustment term to correct for past equilibrium efforts (i.e., βy_{t-1}). ß is the cointegrating vector and α_1 and α_2 measures the speed of adjustment from past equilibrium errors.

The impulse response function

For a certain form of dynamic analysis, the autoregressive representation of data can be inverted to give a moving average representation (MAR). The MAR, as an essential feature of Sims (1980) approach to VAR, allows us to trace out the time path of various innovations (shocks) in the VAR system (Enders, 1993). Since the MAR expresses the series in terms of accumulated current and past shocks in the system, a simulation can be performed in which a variable is perturbed and the resulting response of the system is generated (Freeman et al., 1989). To illustrate this impulse response, let us return to the bivariate first-order VAR in reduced form:

$$\begin{bmatrix} X_t \\ Y_t \end{bmatrix} = \begin{bmatrix} \pi_{11} & \pi_{12} \\ \pi_{21} & \pi_{22} \end{bmatrix} \begin{bmatrix} X_{t-1} \\ Y_{t-1} \end{bmatrix} + \begin{bmatrix} \mu_{1t} \\ \mu_{2t} \end{bmatrix}$$

or in moving average form as :

$$\begin{bmatrix} X_t \\ Y_t \end{bmatrix} = \sum_{k=0}^{\infty} \begin{bmatrix} \pi_{11} & \pi_{12} \\ \pi_{21} & \pi_{22} \end{bmatrix}^K \begin{bmatrix} \mu_{1t-K} \\ \mu_{2t-K} \end{bmatrix}$$

It is insightful to write the innovations in reduced form, μ_{1t} and μ_{2t}, in terms of structural innovations form, ϵ_{1t} ϵ_{2t}. That is

$$\begin{bmatrix}\mu_{1t}\\ \mu_{2t}\end{bmatrix} = \frac{1}{1 - \alpha_{12}\alpha_{21}} \begin{bmatrix}1 & -\alpha_{12}\\ -\alpha_{21} & 1\end{bmatrix} \begin{bmatrix}\epsilon_{1t}\\ \epsilon_{2t}\end{bmatrix}$$

let us define the 2x2 matrix ϕ_K with elements $\phi_{ji}(K)$ such that

$$\Phi_K = \frac{A_1^K}{1 - \alpha_{12} - \alpha_{21}} \begin{bmatrix}1 & -\alpha_{12}\\ -\alpha_{21} & 1\end{bmatrix}$$

and obtain MAR with plug ϕ_K in moving average form of model

$$\begin{bmatrix}X_t\\ Y_t\end{bmatrix} = \sum_{k=0}^{\infty} \begin{bmatrix}\Phi_{11}(k) & \Phi_{12}(k)\\ \Phi_{21}(k) & \Phi_{22}(k)\end{bmatrix} \begin{bmatrix}\epsilon_{1t-k}\\ \epsilon_{2t-k}\end{bmatrix}$$

$$Z_t = \sum_{k=0}^{\infty} \Phi_k \epsilon_{t-k}$$

where $Z_t = (X_t, Y_t)'$, that can be present the responses to one-time unit shock ("impulses") to particular variables. Setting all innovations and levels of the vector equal to zero except ϵ_0 and Z_0, one can trace out the response of the Z vector over time (Bessler, 1984). For instance, ϕ_{12} (0) is the instantaneous (at k=0) impact of one-unit change in ϵ_{1t} on Xt, and simply $\phi_{11}(1)$ and $\phi_{12}(1)$ are the one lag period impact of effects of unit change in ϵ_{1t} and ϵ_{2t} on X_t, that is at one period ahead (K=1). Thus, after n-periods, the cumulated sum of the effects of ϵ_{2t} on series X_t is given as:

$$\sum_{k=0}^{n} \phi_{12}(k)$$

This period-by-period "simulation" can plot out to response of the VAR to a one-time-only shock in a particular series (oil price in this study). This simulating response of the shock that filters in a VAR system may be misleading if the historical data have a strong contemporaneous correlation among innovations. To solve this problem the VAR model can be transformed via the Choleski decomposition method (Doan and Litterman, 1986; Bessler, 1984) as:

$$AZ_t = A\pi_1 Z_{t-1} + A\pi_2 Z_{t-2} + \dots + A\epsilon_t \tag{4.8}$$

Matrix A is sought, such that A $\epsilon_t = \mu_t$, has a variance-covariance matrix equal to the identity I. A triangular matrix is one that has only zeros either above or below the main diagonal. If the zeros are above the diagonal the matrix is lower triangular. Σ denotes variance-covariance of error terms before transformation and $A = H^{-1}$ and H is a lower triangular unique matrix of rank m which selected so that:

$\Sigma = H H'$ and [recall $(H')^{-1} = (H^{-1})'$]

so:

$H^{-1} \Sigma (H^{-1})' = H^{-1} H H' (H')^{-1} = I$

This transformation sets up a "Wold causal chain" among current variables of the X vector, as a contemporaneous model of innovations, alleviating the problem of contemporaneous by correlated errors. In fact, the Choleski decomposition constrains the system such that an ϵ_{1t} shock has no effect on the entire y_t series if we impose, $\alpha_{21} = 0$ in the model. To show how this transformation changes the autoregression representation in a "p" order system we consider reduced form of our example and the relation between errors term after imposing constraint:

$$\begin{bmatrix} 1 & \alpha_{12} \\ 0 & 1 \end{bmatrix} \begin{bmatrix} X_t \\ Y_t \end{bmatrix} = \begin{bmatrix} 1 & \alpha_{12} \\ 0 & 1 \end{bmatrix} \begin{bmatrix} \pi_{11}(1) & \pi_{12}(1) \\ \pi_{21}(1) & \pi_{22}(1) \end{bmatrix} \begin{bmatrix} X_{t-1} \\ Y_{t-1} \end{bmatrix} + \dots$$
$$+ \begin{bmatrix} 1 & \alpha_{12} \\ 0 & 1 \end{bmatrix} \begin{bmatrix} \pi_{11}(P) & \pi_{12}(P) \\ \pi_{21}(P) & \pi_{22}(P) \end{bmatrix} \begin{bmatrix} X_{t-p} \\ Y_{t-p} \end{bmatrix} + \begin{bmatrix} 1 & \alpha_{12} \\ 0 & 1 \end{bmatrix} \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix}$$

As $\mu_{2t} = \epsilon_{2t}$, a unit shock in μ_t is equivalent shock of one standard deviation of ϵ_{2t}.

Note the left-hand side of above equation Y_t has no other current period X_t in its AR representation. However, X_t has current Y_t in its AR representation. Thus, the causal chain in the current period runs from Y to X (Y $\rightarrow$ X) since the contemporaneous system of errors can be written as:

$$\begin{aligned} \mu_{1t} &= \varepsilon_{1t} - \alpha_{12}\,\varepsilon_{2t} \\ \mu_{2t} &= \varepsilon_{2t} \end{aligned}$$

Of course, if the contemporaneous correlation between residuals (innovations) is weak, the off-diagonal elements of Σ are close to zero, then the resulting causal chain is not sensitive to the ordering of variables in the model. In other words, when little correlation exists between variables, the order of factorization makes little difference. However, when σ_{ij} (for $i \neq j$) is not zero, the analyst must rely on a prior knowledge in selecting the ordering in a VAR and where economic theory is informative on instantaneous correlation, it should be used.

Forecast error decomposition

The purpose of decomposition of forecast error is to determine the proportion of each of the variable's forecast errors that is attributable to each of orthogonalized errors (shocks) in the VAR model. If we forecast a variable it will have an error forecast that comes partly from past errors of this forecasting and other variables in a VAR model. Therefore, the standard error of forecasting increases as the forecast horizon increases. By decompositing the variance of forecast error we can measure the effects that variables have on each other over time, that is, the decomposition provides an estimate of the amount of influence variables in a dynamic response to shocks in a particular variable. From Granger and Newbold (p. 229) the optimal forecast by using autoregression and information available in period t for k periods ahead may be expressed as:

$$f(t,k) = \sum_{i=0}^{\infty} \phi_{i+k} H \mu_{t-i}$$

The matrices ϕ and H are defined as before and assumed to be known. The k periods ahead forecast error is :

$$\epsilon(t,k) = X(t+k) - \delta(t,k) = \sum_{i=0}^{k-1} \phi_i \mu_{tk-i} \qquad (4.9)$$

Where ϕ = IH. This expression gives the k th period ahead forecast error of X_t as a moving average process with order k-1. The variance of this error can be written as:

$$V(k) = \sum_{i=1}^{k-1} \phi_i \phi_i' .$$

As mentioned above the decomposition of forecast error variance presents the variation in series i accounted for by shocks in series j. Hence, the percentage of forecast error variance in series i that is explained by the shock in series j can be expressed as :

$$PFE_{ij}\, k = \frac{\sum_{t=1}^{k-1} \tilde{\phi}_{ij}(k)^2}{\sum_{j=1}^{m}\sum_{k=1}^{k-1} \tilde{\phi}_{ij}(k)^2} ;$$

where m refers to number of series in the system.

In the bivariate VAR (1) example, if shocks in the second process, Y_t, i.e., ϵ_{2t}, explain none of the forecast error variance of X_t, we can say that X is exogenous in the system. Decomposition of forecast errors provides an interesting alternative to the usual test of Granger causality. While Granger causality is defined in terms of difference of variance forecasting error (see Chapter 5) in a given information set, forecast error decomposition is defined in terms of forecast error variance with a full information set. Thus, for example, for some i and j, finding $\phi_{ij}(0) = \phi_{ij}(1) = \phi_{ij}(k-1) = 0$, will generally not be equivalent to the statement "series j does not Granger cause series i." The PFE_{ij} give us a useful measure of strength of "explanation" at different forecast horizon, while the standard F-test of causality will not provide such dynamic information. In other words, the standard causality test allows the researcher to make existence-type statements, i.e., the causality linkage exists or not, while forecast error decomposition allows inferences with respect to strength and timing of similar relationships (Bessler, 1984).

Empirical Results

Model specification

To explore the dynamic relationship among the most important vaiables that influence food security in an oil exporting country and show the impact of a shock in one of those variables on other variables, we construct a five-equation VAR that can be represented as a reduced form by:

$$OP_t = A_1^1(L)\ OP_t + A_2^1(L)\ Y_t + A_3^1(L)\ Q_t + A_4^1(L)\ M_t + A_5^1(L)\ C_t + \mu_{op} \quad (4.10.1)$$

$$Y_t = A_1^2(L)\ OP_t + A_2^2(L)\ Y_t + A_3^2(L)\ Q_t + A_4^2(L)\ M_t + A_5^2(L)\ C_t + \mu_Y \quad (4.10.2)$$

$$Q_t = A_1^3(L)\ OP_t + A_2^3(L)\ Y_t + A_3^3(L)\ Q_t + A_4^3(L)\ M_t + A_5^3(L)\ C_t + \mu_Q \quad (4.10.3)$$

$$M_t = A_1^4(L)\ OP_t + A_2^4(L)\ Y_t + A_3^4(L)\ Q_t + A_4^4(L)\ M_t + A_5^4(L)\ C_t + \mu_M \quad (4.10.4)$$

$$C_t = A_1^5(L)\ OP_t + A_2^5(L)\ Y_t + A_3^5(L)\ Q_t + A_4^5(L)\ M_t + A_5^5(L)\ C_t + \mu_C \quad (4.10.5)$$

where OP is oil price; Y is real per capita income; Q is domestic food (wheat) production; M is food imports; and C is food utilization. $A_i^j(L)$ is a lag polynominal operator for i, j = 1,...5. By construction, the residuals (innovations), μ_t, are serially uncorrorelated, but may be contemporaneously correlated. The system to facilitate discussion, may be written compactly as,

$$X_t = A(L)\,X_t + \mu_t \qquad (4.11)$$

where X is a 5X1 vector of variables, A(L) is 5X5 lag polynominal matrix and μ is a 5X1 VAR residual vector (shocks vector), and we assume:

$$\begin{aligned} A(L) &= A_1 + A_2(L) + A_3(L^2) + \ldots \\ E(\mu_t) &= 0 \\ E(\mu_t \mu_t') &= \Sigma \\ E(\mu_t \mu_s') &= 0 \quad \text{for} \quad t \neq s \\ E(X_t \mu_s') &= 0 \quad \text{for} \quad \text{all} \quad t < s \end{aligned}$$

Error (shock) structure

In general, the covariance matrix of innovations, $\sum$, is nondiagonal symmetric since the unrestricted VAR residuals may be contemporaneously correlated. Some effort must be made to account for this correlation if a realistic simulation is to be performed. If we assume they are independent, as one possibility, we ignore the important informaiton that could be obtained from estimation. It is useful to transform these correlations into contemporaneous effects by applying an appropriate factorization method, such as the Choleski decomposition mentioned in the previous section and set the decomposing error covariance matrix, $\sum$, as a comtemporaneous model, into a "chain causal" form. This kind of organizing of the contemporaneous effect based on orthogonalization of the remaining error is justified by the presumption that behaviorally distinct sources of variation should be independent of another (Freeman et al. 1989). The choice of ordering of a causal chain of contemporaneous effects is very important since the results usually are sensitive to this ordering. Since Choleski orthogonalization has a lower triangular factor, the shock as the first variable has an "immediate" impact on all other variables in the system. Shocks as a second variable, on the other hand, have an "immediate" affect on all but the first variable in that ordering, and so on. If we applied Choleski decomposition and chose the ordering as OP, Y, Q, M, and C the system is of the form:

$$
\begin{aligned}
\mu_{t,op} &= \varepsilon_{op} \\
\mu_{t,y} &= \beta_1\mu_{t,op} + \varepsilon_y \\
\mu_{t,Q} &= \beta_2\mu_{t,op} + \beta_3\mu_{t,y} + \varepsilon_Q \\
\mu_{t,M} &= \beta_4\mu_{t,op} + \beta_5\mu_{t,y} + \beta_6\mu_{t,Q} + \varepsilon_M \\
\mu_{t,c} &= \beta_7\mu_{t,op} + \beta_8\mu_{t,y} + \beta_9\mu_{t,Q} + \beta_{10}\mu_{t,M} + \varepsilon_c
\end{aligned}
$$

All ϵ's are structurally orthorgonalized innovations; that is $E(\varepsilon_t \ \varepsilon_t)'$ is a diagonal matrix and β's are the coefficients linking underlying shocks to reduced form error, μ's. In the above chain of causality among the shocks in any given year, we assumed the shock or surprise movement in oil price effects all other variables, and shocks in per capita income have two components: $\beta_1\mu_{t,op}$, which reflects the intra-year effect of oil price shock and ϵ_y, which represents the underlying random shock in income at time t. We assumed $\mu_{t,Q}$ has three components: $\beta_2\mu_{t,op}$ to reflect the intra-year effect on Q of shock to oil price; $\beta_3\mu_{t,y}$, to reflect the intra-year effect on Q of random shock in Y; and ϵ_Q to represent the remaining surprise movement in Q at time t. The other equations have similar explanations, the last variable in this ordering, C, has an immediate impact only on itself.

Testing of properties of data

The procedure to build an Error-Correction Model (ECM) for causality test of all variables under study in a food security context, involves three steps. First, the order of integration for each time series is determined. If a variable is nonstationary, with a unit root, it will be successively differenced until stationarity is obtained. Most economic time series after first-differencing will be stationary. Second, if variables are nonstationary but some linear combinations between these are stationary, that is, they are cointegrated, then by applying some techniques such as Johansen-Jelesius Procedures, we can identify the number of cointegrating vectors. Finally, we estimate error and correction VAR and using that to explore Granger causality linkages and present the dynamic responses of variables due to a shock in each variable.

Stationarity test (unit root test)

In the Box-Jenkins' identification stage, there are three ways to test if the stationarity requirement is met:

(i) Examine the realization visually to see if either the mean or the variable appears to be changing over time,

(ii) Examine the estimated Auto Correlation Function (ACF) to see if it moves rapidly toward zero,

(iii) Examine any estimated AR coefficients to see if their sum is less than one (Pankratz, 1983).

A visual test of all variables, based on the above guidelines shows, they are nonstationary, except wheat production in Algeria. As a formal test, the procedure of the unit root test developed by Fuller (1976) and Dicky and Fuller (1979) are applied to examine the order of integration of variables. If we write the time series model in the following way it can express both types of processes we discussed earlier, i.e., (TSP) and (DSP) processes:

$$X_t = \alpha_1 + \alpha_2 t + \rho X_{t-1} + \epsilon_t \tag{4.12}$$

Under $\rho < 1$ and $\alpha_2 \neq 0$, X_t is said to be a trend stationary process while X_t is DSP if $\rho = 1$ and $a_2 = 0$. The usual t-statistic for testing $\rho = 1$ by OLS can lead one to incorrectly reject the nonstationary hypothesis. One can reparametrize equation 4.12 into 4.13 by subtracting X_{t-1} from both sides of equation (4.12).

$$\Delta X_t = a_1 + a_2 t + (\rho-1) X_{t-1} + \epsilon_t \tag{4.13}$$

where ΔX_t is the first difference of X at time t, $\Delta X_t = X_t - X_{t-1}$. By applying the ordinary least square (OLS) method we can estimate the model and compare ρ-1 with the critical value provided by Fuller (1976, p. 373). Since in this Dickey-Fuller (DF) test, it is assumed the error terms are serially uncorrorelated, we may account for this assumption and rewrite (4.13) as:

$$\Delta X_t = a_1 + a_{2t} + (\rho-1) X_{t-1} + \sum_{j=1}^{n} \varphi_i \Delta X_{t-j} + \varepsilon_t \tag{4.14}$$

and choose n so that the residuals are uncorrelated. Again the critical values to compare with statistics used for the test, are contained in by Fuller. This procedure is called augmented Dickey-Fuller (ADF) test. In both cases, i.e., the DF and ADF, Dickey and Fuller (1979) consider three regression (a pure random walk, with drift but without time trend, and with time trend) equations that can be used to test for the presence of a unit root. We applied the regression equations with and without trend to test nonstationary for all variables in ADF and only without trend in DF procedure and the results reported in Table 4.1. We used one lag length to remove the problem of serial correlation.

To reject the null hypothesis of unit root for both DF and ADF test, the statistic of coefficient of X_{t-1} must be smaller than critical values that calculated based on suggestion of MacKinno (1990) and reported in Table 4.2.

Since Dickey-Fuller tests assume that the errors are statistically independent and homogenous, we apply, as a secondary test, the Philipps and Peron (1988) test which allows for fairly mild assumptions concerning the distribution of the error (see Enders, 1994). The critical values for the Phillips-Peron statistic use precisely those given for the Dickey-Fuller test. In summary, as Table 4.1 shows, at 5 percent and 1 percent significance levels, for all vairables, expect wheat production in Algeria, we fail to reject the null hypothesis of a unit root in DF, ADF, and Phillips-Peron tests. The results of unit tests after first-differencing the data reported in Table 4.3 indicate that each series is characterized as a nonstationary I(1) process after first differencing it will be a stationary process.

Table 4.1. Unit root test (1960-1991)
[levels]

Series	DF (with trend)	(a) ADF (with trend)	(b) Z (no trend)	Z (with trend)
AQ	-5.46	-4.88	.01	-5.75
IQ	-4.09	-3.57	-1.28	-4.33
SQ	-0.80	0.42	3.34	0.76
AM	-2.79	-3.03	-0.17	-2.90
IM	-3.68	-2.75	-0.82	-3.84
SM	-2.10	-1.24	-2.09	-1.97
AC	-3.78	-2.23	0.81	-3.96
IC	-3.92	-2.94	0.60	-4.10
SC	-2.31	-2.01	0.90	-2.41
AY	-3.35	-2.87	0.01	-3.52
IY	-1.23	1.44	-1.59	-1.38
SY	-0.22	-1.25	-1.32	-0.60
AOP	-0.94	-1.35	-1.50	-1.19
IQP	-1.07	-1.04	-1.52	-1.15
SOP	-2.54	-2.01	-2.14	-2.63

(a) First order autocorrelation adjustment is used for ADF test.
(b) One lag length is used for the Philips-Peron test.
For the sample size of 25, at 1%, 5%, 10% critical values with time trend are -4.38, -360, 3.24 and for no trend regressions are -3.75, -3.00, -2.62 that given in Fuller(1976). Also, see critical values that calculate by auther in table 4.2 based on MacKinnon(1990).

Table 4.2. Critical values (Sample size = 32)

	(1%)	(5%)	(10%)
no-trend	-3.66	-2.96	-2.62
with trend	-4.28	-3.56	-3.21

Calculated based on MacKinnon(1991)

Lag length test

One basic issue in VAR analysis is the choice of appropriate number of lags. Several methods have been forwarded to determine a desirable length. Sims(1980) has selected lag length based on sample size, and arguing that conventional likelihood ratio test is too conservative in favor of acceptance of null hypothesis. He suggested a modified likelihood ratio statistic:

$$L(l) = (T-C)\ (Ln/\Sigma_R/ - Ln/\Sigma_u/) \tag{4.15}$$

where T is the number of observations, C is a correction to improve small sample properties (He recommended that C equal the number of parameters estimated in the unrestricted system), and Σ_R and Σ_U are determinants of variance/covariance matrix of the residuals in restricted and unrestricted models, respectively.

Under null hypothesis, this statistic, L(l), converges to $\chi 2(df)$ where the degree of freedom, (df), is the number of linear restrictions. Table 4.4 contains the results of optimal lag length test. According the lag length test, one lag is appropriate for the Algeria and Iran VAR models. For the Saudi Arabia VAR model, the test results suggest longer structural lags than one, but due to data limitations (i.e., exhausting the degrees of freedom with longer lags and inconsistency of dynamic responses of VAR model with higher order than one) we specify a VAR(1) model for all the countries in the study.

Table 4.3. Unit root test (1960-1991)
[first difference]

Series	DF (with trend)	(a) ADF (with trend)	(b) Z (no trend)	Z (with trend)
AQ	-8.06	-5.86	-8.86	-5.86
IQ	-6.98	-5.23	-7.43	-7.44
SQ	-4.59	-2.99	-3.04	-4.83
AM	-6.14	-4.54	-6.23	-4.54
IM	-7.70	-7.00	-8.26	-8.46
SM	-8.51	-4.48	-8.72	-9.02
AC	-9.55	-5.90	-9.96	-5.90
IC	-8.90	-7.09	-9.56	-10.08
SC	-6.05	-5.66	-6.08	-6.40
AY	-5.50	-3.75	-5.72	-3.75
IY	-4.60	-3.34	-4.70	-4.85
SY	-3.43	-3.06	-3.46	-3.64
AOP	-4.28	-3.49	-4.37	-3.49
IOP	-5.45	-3.42	-5.47	-5.74
SOP	-6.58	-4.24	-6.96	-6.95

(a) First order autocorrelation adjustment is used for ADF test.
(b) One lag length is used for the Phillips-Peron test.
For the sample size of 25, at 1%, 5%, 10% critical values with time trend are -4.38, -360, 3.24 and for no trend regressions are -3.75, -3.00, -2.62 that given in Fuller(Also, see critical values that calculated by author in table 4.2 .

Table 4.4. Lag length test

Model	1 VS. 2(a)	2 VS. 3	1 VS. 3
Algeria- VAR Model	28.84 (0.270)	30.54 (0.205)	50.64 (0.446)
Iran- VAR Model	37 (0.058)	32.96 (0.131)	58.83 (0.184)
Saudi Arabia- VAR Model	46.3 (0.006)	47.66 (0.004)	81.78 (0.003)

(a) Numbers are Likelihood Ratio statistic, L(l); numbers in parentheses are marginal significance levels.

Critica values of Chi - Squared for 25 and 50 degree of freedom are 37.65 and 67.50 , at 5% , respectivly.

Testing for cointegration

Engle and Granger (1987) offered several tests for cointegration, but three have emerged as the most popular choices. The cointegration regression Durbin-Watson (CRDW) test, the Dickey-Fuller (DF) and Augmented Dickey-Fuller (ADF) test (Dickey Fuller, 1979 and 1981). If there is a unit root, that is, if a linear combination between X_t and Y_t is nonstationary, then there is no cointegration. Based on previous discussion about TSP and DSP, we can use a general model,

$$X_t = \alpha_1 + \alpha_2 t + \rho X_{t-1} + \varepsilon_t \qquad (4.16)$$

where ϵ_t is random error term with constant mean and variance. If $\rho = 1$ and $a_2 = 0$ then X_t has a unit root and is thus nonstationary in levels, but stationary after first differencing, i.e., it is a DSP. If $\rho < 1$ and a_2 is non-zero, then X_t is nonstationary in levels and stationary in deviation around the trend, i.e., after detrending, it is a TSP. X_t should be stationary itself if $\rho < 1$ and $a_2 = 0$. The usual t-statistic for testing the null hypothesis that ρ is equal to one is not valid here. Therefore, we can reparametize equation 4.16 into 4.17 by adding X_{t-1} on both sides of equation 4.16.

$$\Delta X_t = \alpha_1 + a_2 t + (\rho-1) X_{t-1} + \varepsilon_t \qquad (4.17)$$

where $\Delta = (1\text{-}L)$ and L is the lag operator. In this DF test, we estimate the equation 4.17 with the ordinary least squares (OLS) method and compare the t-statistic of coefficient of X_{t-1} with the critical values provided in Fuller (1976, p.737). The Augmented Dickey-Fuller (ADF) test provides a single generalization of the DF test to allow for the possibility of higher-order autoregressions

$$\Delta X_t = a_1 + a_2 t + (\rho - 1) X_{t-1} + \sum_{j=1}^{K} b_j \Delta X_{t-j} + \mu_t \tag{4.18}$$

where K, the number of lagged differences, is chosen so as to eliminate any autocorrelation in the residual, μ_t. Another "conventional" cointegration test suggested by Engle and Granger (1987) (also called the two-step procedure) involves testing for unit roots to determine the order of integration of the individual series. If all the variables are integrated of the same order, such as in our study d=1, then OLS regression can be applied to obtain the cointegration vector, say α.

After the cointegrating vector is found, testing for cointegration amounts to applying unit-root tests to the residuals obtained from the cointegration equation and checking whether they are I(d-b), where b > 0. The hypothesis is no cointegration against the hypothesis of cointegration. As mentioned earlier, when more than two variables are involved, the cointegrating vector may not be unique. Consider the two variables case again. Suppose each of which is cointegrated of order one, $X_t \sim I(1)$ and $Y_t \sim I(1)$. Now if $(X_t\ Y_t)$ cointegrated with parameter α then:

$$\varepsilon_t = X_t - \alpha Y_t \tag{4.19}$$

where $\epsilon \sim I(0)$ and α is unique. To see this uniqueness, suppose we had another cointegrating parameter β:

$$\omega_t = X_t - \beta Y_t \tag{4.20}$$

ω ~I(0), by adding and subtracting βY_t in 4.19, we have

$$\varepsilon_t = X_t - (\alpha - \beta)\, Y_t - \beta Y_t \tag{4.21}$$

that is,

$$\varepsilon_t = \omega_t - (\alpha - \beta)\, Y_t \tag{4.22}$$

By assumption, ϵ_t and ω_t are both I(0) while Y_t is I(1). The latter three conditions can bold only if $\alpha = \beta$ that is α is unique. In more than two variables, in N variables case, each integrated of same order, then there can be up to (N-1) cointegrating vectors (Cuthertson, 1992). Because all variables in this study are I(1), except Algeria wheat production (AQ), if they are cointegrated, one or more distinct linear combinations of these time series could be stable in the long-run. To test for cointegration, the Johanson-Juselius maximum likelihood procedure is applied. The method begins with an unrestricted VAR of N-dimentional variables X in the levels of the variables:

$$X_t = \Pi\text{-}1\ X_{t-1} + \ldots\ldots + \Pi_K\, X_{t-k} + e_t \tag{4.23}$$

where each of the Π_i is an (N x N) matrix of parameters, and e is an independent and identically (normally) distributed vector of disturbances. The procedure is based on the error-correction version of the equation:

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} + \Gamma_2 \Delta X_{t-2} + \ldots + \Gamma_{k-i} \Delta X_{t-k+1} + \psi_k X_{t-k} + e_t \qquad (4.24)$$

where

$$\psi_i = -I + \Pi_1 + \ldots + \Pi_i , \qquad i = 1, \ldots, k$$

Thus, ψ_k now defined the long-run "level solution" to 4.24. Consider an Nxr matrix β such that $\beta' X_{t-k} \sim I(0)$. If all the elements of X_t are I(1), the column of β must form cointegrating vectors for X_{t-k} and hence X_t are not cointegrated, then β must be a null matrix. Now define another (N x r) matrix α such that:

$$\Pi = \psi_k = -\alpha\beta' \qquad (4.25)$$

The number of cointegration vectors can be determined by applying identification of rank of the Π matrix.

Johansen and Juselius show that if the rank is zero, the variables are not cointegrated. However, if the rank is r, there are r unit possible independent stationary linear combinations. For example, if we assume there is only one cointegrating vector, r = 1, then we need to consider only the first column in the system of α and β, and 4.23 can be written:

$$\Delta X_t = \Gamma_1 X_{t-1} + \Gamma_2 \Delta X_{t-2} + (-\alpha_1 Z_{t-k}) + e_t \qquad (4.26)$$
$$Z_t = \beta_1 X_t \sim I(0)$$

Table (4.5) shows the results of Johansen and Juselins test for all VAR models for all countries under study at the 5 percent level. Table indicates that there is only one cointegrating vector in each model, and therefore, one correction term is included in the estimation VAR model for each country model. Diagnostic test statistics for the models are presented in Table 4.6. Based on Ljung-Box Q

Table 4.5. Johansen Cointegration Test Results

	Algeria model		Iran model		Saudi Arabia model		5% Critical Values	
Ho	Trace (a)	max (b)	Trace	max	Trace	max	Trace	max
r=0	95.17*	48.55*	61.62	34.41	133.49*	50.46*	70.60	33.32
r<=1	46.63	24.09	27.22	17.98	83.04*	44.51*	48.28	27.14
r<=2	22.53	18.50	9.24	5.91	38.52*	23.46*	31.53	21.04
r<=3	4.03	3.95	3.32	3.32	15.06	12.11	17.95	14.9
r<=4	0.08	0.08	0.02	0.02	2.95	2.95	8.18	8.18

(a) * indicates rejection at 5% of the null hypothesis of at most r stationary linear combinations of the series against the alternative of possible stationarity of all series.
(b) * indicates rejection at 5% level of the null hypothesis of at most r stationary linear combinations of the series against the alternative of at most r+1 such combinations

Table 4.6. Diagnostic tests for EC - VAR models

	Algeria Model		Iran Model		S. Arabia Model	
	Ljung-Box(a)	Jarque-Bera(b)				
Equation	Q-Statistic	Normality Test	(a)	(b)	(a)	(b)
OP	2.80	4.14	4.49	30.20*	10.96	2.34
Y	2.88	5.99	2.52	15.21*	7.67	1.98
Q	6.72	17.33*	9.66	2.76	5.8	2.79
M	6.33	11.52*	6.13	4.62	3.51	.37
C	10.33	3.30	6.33	7.43	22.02*	2.84

(a) Ljung-Box Q-Statistic is distributed as X (7). The null hypothesis of no serial correlation is rejected at 5% significance level if the Q-statistic is larger than 16.01.
(b) Jarque-Bera statistic is distributed as X (2). The null hypothesis of normality is rejected at 5% significance level if the test statistic is larger than 7.38.
* significant at 5%.

statistic, the estimated equations are free of serial correlation problems of significance at a 5 percent level, except for wheat consumption in Saudi Arabia. The null hypothesis of no serial correlation is rejected for SC equation at the 5 percent significance level, but not at the 1 percent level. Jarque-Bera statistics indicate that most estimated residuals pass normality test, a relatively important assumption in Johansen and Juseling maximum likelihood test. However, based on Q-statistics, for purposes of this study, the estimated equations seem adequate.

The causality test and error-correction models

On an intuitive level, as mentioned earlier, the standard Granger Causality test examines whether past changes in one variable, Y, help to predict changes of another variable, X, over and above the using past changes of Y. If not, the conclusion is that Y does not Granger cause X. It is assumed X_t and Y_t are stationary but when this is not the case and these variables are cointegrated, we know the X_{t-1} and Y_{t-1} are also cointegrated and there is Granger Causality in at least one direction between two variables concerned (Granger, 1988). Cointegration itself has nothing to say about direction of causality between variables, for tjis reason testing for causality is required.

Granger (1983) and more recently Engle and Granger (1987) provide a more comprehensive test of causality, which allows testing of causality in the cointegrated variables case. This alternative to the standard test for Granger causality considers the possibility that the lagged 'level' of a variable, Y, may help to predict the X, even if past changes in Y do not. Such causality linkages may not be detected by standard Granger Causality testing, which examines the past changes in one variableto predict another variable. More formally the standard causality Granger test is based on the following regression order (n):

$$\Delta X_t = \alpha_o + \sum_{j=1}^{n} \beta_{1j} \Delta X_{t-j} + \sum_{j=1}^{n} \beta_{2j} \Delta Y_{t-j} + \mu_t \qquad (4.27)$$

where Δ is the first-difference and ΔX and ΔY are stationary. The null hypothesis that "Y does not Granger Cause X" is rejected if coefficients β_{2j} are jointly significantly different from zero based on a standard F-test. In this standard, procedure the finding no causality in either direction is ruled out when the variables share a common trend, that is they are cointegrated (Miller and Russek, 1990). In case the variables are cointegrated and ECM is used for testing the direction of causality such as:

$$\Delta X_t = \alpha_o + \sum_{j=1}^{n} \beta_{1j} \Delta X_{t-j} + \sum_{j=1}^{n} \beta_{2j} \Delta Y_{t-j} + \alpha_1 \varepsilon_{t-1} + \mu_t \qquad (4.28)$$

where X_t and Y_t after first-difference are stationary and cointegrated and where ϵ_{t-1} is the lagged (past) value of error term from the following cointegration equation:

$$Y_t = \beta X_t + \varepsilon_t \qquad (4.29)$$

By including ϵ_{t-1} in the previous model and get ECM for using in causality Granger test allows for finding that Y Granger cause X, even if the coefficients on lagged changes in Y are not jointly significant. In other words, based on ECM, the null hypothesis that "Y does not Granger cause X" is rejected not only if β_{2j}'s are jointly significant, but also if the coefficient on ϵ_{t-1} is significant.

Based on causality test and using F-statistic for single-equation in the EC VAR model in each country, we can summarize the causality results as: in Algeria, per capita income is Granger cause of wheat production at 10 percent level of significance. The oil price and consumption itself, at 1 percent level and per capita income, at 10 percent level of significance, are Granger cause of wheat consumption.

In Iran, wheat consumption is Granger-cause of wheat imports, at 5 percent level of significance, and the error-correction terms also are significant.

In Saudi Arabia, at 10 percent level of significance, wheat imports is Granger-cause of wheat production.

Forecast error variance decomposition

Tables 4.7 through 4.9 present the percentages of the forecast error variation of three series that are explained by themselves and other variables in the system. The results for oil price and per capita income shows that their variation is explained only by themselves, that is these two series are exogenous in the system. Hence, only the results for the other three variables are reported.

As can be seen in Table 4.7, about 56 percent of the forecast error variation for wheat production in Algeria, (DAQ) is explained by innovations in the series by itself in the short run (one year) and about 43 percent by income shock. In the long run the impact of the DAQ variation decrease while of income increase. Innovations in the wheat production and income explain about 28 percent of forecast error variation in wheat imports, while the shock in wheat imports attributed 43 percent by itself at one year period ahead. In the short run, the

Table 4.7. **Percentage of forecast error variance K year(s) ahead each innovation (a) [Algeria]**

Series	K	Standard Error	Innovation				
			DAOP	DAY	DAQ	DAM	DAC
DAQ	1	400.16	.85	43.13	56.02	0.00	0.00
	3	459.76	1.91	47.77	47.15	.27	2.90
	5	463.51	2.79	47.16	46.47	.45	3.13
	7	463.69	2.83	47.13	46.44	.47	3.13
	10	463.67	2.83	47.13	46.44	.47	3.13
DAM	1	312.73	.17	28.16	28.22	43.44	0.00
	3	367.72	5.03	27.55	27.18	38.67	1.57
	5	370.97	5.36	27.44	27.18	38.02	2.01
	7	371.25	5.42	27.42	27.16	37.96	2.04
	10	371.27	5.43	27.42	27.15	37.96	2.04
DAC	1	205.33	7.36	3.34	30.13	18.23	40.95
	3	286.47	36.70	3.89	18.41	12.19	28.80
	5	288.48	37.05	3.93	18.19	12.24	28.59
	7	288.54	37.06	3.93	18.18	12.25	28.58
	10	288.54	37.06	3.93	18.18	12.25	28.58

(a) DAOP = Oil Price ; DAY = Income ; DAQ = Wheat Production ; DIM = Wheat Imports; DAC = Wheat Consumption

Table 4. 8. **Percentage of forecast error variance K year(s) ahead attributed to each innovation (a) [Iran]**

Series	K	Standard Error	Innovation DIOP	DIY	DIQ	DIM	DIC
DIQ	1	611.38	4.21	5.08	90.71	0.00	0.00
	3	641.74	7.23	7.78	84.35	.42	.22
	5	642.81	7.26	7.86	84.20	.43	.25
	7	642.83	7.26	7.86	84.19	.43	.25
	10	642.84	7.26	7.86	84.19	.43	.25
DIM	1	536.31	14.60	.24	31.50	53.66	0.00
	3	605.00	12.70	8.38	28.36	44.08	6.49
	5	607.45	12.60	8.69	28.49	43.74	6.48
	7	607.53	12.61	8.69	28.49	43.74	6.48
	10	607.54	12.61	8.69	28.49	43.73	6.48
DIC	1	428.73	2.91	.27	4.18	54.37	38.26
	3	502.81	6.39	7.21	4.19	49.51	32.69
	5	504.36	6.34	7.36	4.25	49.40	32.62
	7	504.40	6.36	7.36	4.25	49.40	32.62
	10	504.41	6.36	7.36	4.25	49.40	32.62

percentages of the unexpected variations in oil price, wheat production, and wheat imports account for 7, 30, and 18 percent of variation in wheat consumption in Algeria, respectively.

In the short run wheat consumption variation explained about 41 percent of its own variation. After 2 years, oil prices appear to play increasing role in explaining the variation in the wheat consumption, 36%, and in long run this proportion is sustained at 37% and represents the dominating source of variation in food security in Algeria. On the other hand, as reported in columns 4, 5, and 6 (Table 4.7), the importance of wheat production, wheat imports, and wheat consumption shocks decreases after first period and remain stable over time.

The results for the Iran data are reported in Table 4.8. The fourth column of Table 4.8 indicates that the wheat production shock exerts a very significant impact on unexpected wheat production variation, 91%, in short run, while the share of shocks of other variable are relatively insignificant. Within one year the shocks in oil price, wheat production, and wheat imports accounts for about 15%, 32%, and 54% of the unexpected variation in wheat imports, respectively. The impact decrease after year 1 and remains stable over time. The Table 4.8 also indicates that 38% of variation in food (wheat) consumption is explained by its own innovations. In the first, year wheat imports are the predominant "other" variable in explaining wheat consumption variation and this major impact is sustained over time. A shock in the oil price exerts only a modest effect on wheat consumption after the first year.

The forecast error variance decomposition of food security variables in Saudi Arabia is reported in Table 4.9. Column 2 shows that oil prices shock exerts a

Table 4.9. Percentage of forecast error variance K year(s) ahead attributed to each innovation (a) [Saudi Arabia]

Series	K	Standard Error	Innovation DSOP	DSY	DSQ	DIM	DIC
DSQ	1	129.63	21.49	3.10	75.41	0.00	0.00
	3	166.01	15.10	13.88	58.00	0.42	0.22
	5	170.66	15.86	14.27	55.41	0.43	0.25
	7	170.87	15.95	14.27	55.27	0.43	0.25
	10	170.87	15.95	14.27	55.27	0.43	0.25
DSM	1	177.01	0.08	33.74	26.43	53.66	0.00
	3	208.44	1.41	33.94	23.05	44.08	6.49
	5	209.88	1.82	33.78	22.79	43.74	6.48
	7	209.91	1.83	33.77	22.78	43.74	6.48
	10	209.91	1.83	33.77	22.78	43.73	6.48
DSC	1	57.57	0.23	3.33	5.50	54.37	38.26
	3	64.93	11.00	5.06	9.67	49.51	32.69
	5	65.13	10.95	5.25	9.74	49.40	32.62
	7	65.15	10.95	5.26	9.74	49.40	32.62
	10	65.15	10.95	5.26	9.74	49.40	32.62

(a) DSO = Oil Price; DSY = Income; DSQ = Wheat Production; DSM = Wheat Consumption; DSC = Wheat Consumption modest impact on wheat production and wheat consumption (except in the initial period) and has a very insignificant impact on wheat imports. The shock in wheat production accounts as a major source of variation in wheat production, 55% even at year 10. The Table 4.9 also shows the forecast error variation in wheat imports; mainly explained by itself and income and production of wheat, respectively. In short run wheat consumption nearly looks exogenous, while in long run wheat production and oil prices have a modest effect on variation of food(wheat) consumption.

Column 1 in forecast standard error increases towards a upper bound for each of the series. This indicates that the system is stationary. To sum up the discussion so far, the results indicate the oil price shocks have the most impact on food consumption in Algeria in the short and long run, and have lowest impact in the short run in the Saudi Arabia and in Iran in long run. In the short run, the main source of variation in wheat consumption is wheat consumption itself in Saudi Arabia and Algeria, while in Iran this source is wheat imports. In the long run, the main source of instability in food security in Algeria is oil prices, in Iran is wheat imports, and in Saudi Arabia is wheat consumption.

Impulse Responses

The VAR system can uncover the total impact of the changes in the variables. Given the moving average representation of the model, the impulse response functions trace out both the contemporaneous and cummulative lagged adjustments on standard deviation (typical) shock of a single variable, say oil price, to another variable. This provides the important information about not only the magnitude of total impact (large or small), but also the direction of relationship of variables (direct or inverse), and the persistance of the effect of the given shock over time (short-lived or permanent). The VMAR is used to generate the impulse response function, and variance decomposition. The equation ordering used to orthogonalize the innovations (shocks) for impulse responses was OP-Y-Q-M-C. To facilitate comparability, the response of each variable was divided by the square root of its residual variance so that responses are expressed in terms ofnumber of standard deviations.

Figures 4.1 through 4.3 show the responses of the five variables involved in food security to a one standard deviation (typical) shock in the oil price in Algeria, Iran, and Saudi Arabia, respectively. Each function was traced through 10 time periods (years). This time frame was considered long enough for most responses to occur, equivalent to two economic planing periods in each country.

Figure 4.1 report the responses of all variables in the system to a one standard deviation shock in oil price in Algeria at year 1. The impulse response function suggests that the impact of a shock in oil price is an immediate .28 standard deviation decrease in real per capita income (AY) suggesting the importance of oil export earning in Algeria's economy, but that the impact in third year is positive and thereafter is not significantly different from zero and, completely disappear after year 5. The oil price shock generates a negative response only in the second period indicating the lag response. Thereafter, wheat production follows an oscillatory path toward zero lasted more than AOP and AY responses. The initial response of consumption and import are positive and osillats thereafter. The impulse response for AM and AC follow each other directly for early years and after year 3, consumption response follow imports with a lag. The increased oil price initially increase wheat consumption but decreased substantially at year 2 and return to preshock levels at year 5 and beyond.

Figure 4.2 shows the responses of all variables in Iran to a one standard deviation shock in oil price at year 1. The figure present initially that an increased oil price has a positive impact on all variable in the system except wheat production (IQ). This seems to be consistent with "Dutch Disease" problem, that is when the oil price increased sharply the resources from traded sector of economy, i.e., agricultural and industrial, moved to oil sector and this movement of resource decrease the production of traded goods including wheat. The impact of shock in oil price on wheat consumption is large in the short run and disappears beyond 3 years.

Figure 4.3 shows the impact of shock in oil price in Saudi Arabia. The initial shock in oil price results to a positive impact on all variables in the system. Two interesting parts are: the production responses to oil price shock is more sustainable, i.e., one or more year after the initial shock, and in spite of the oil price falling down after year 1, the wheat consumption increased substantially. This appears consistent with the "permanent income" hypothesis in oil revenue.

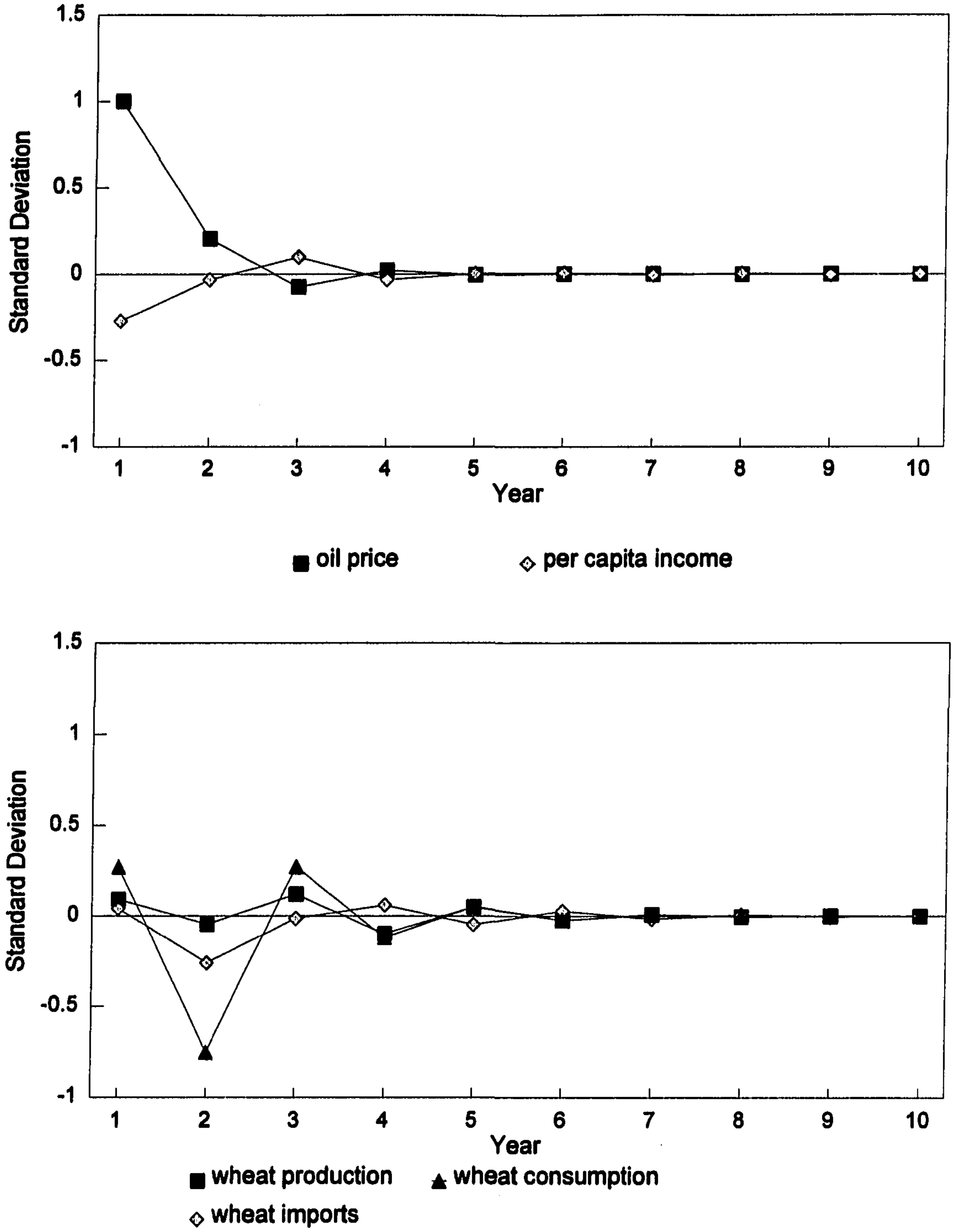
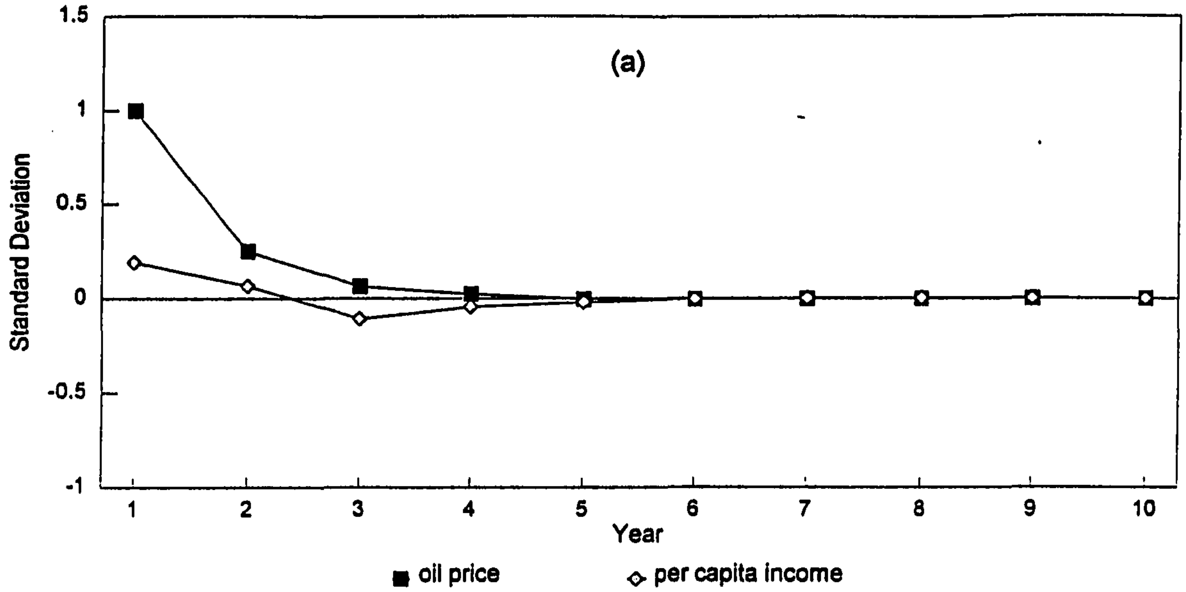


Figure 4.1. Responses to an oil shock in Algeria

(a) oil price and per capita income responses
(b) wheat production, wheat imports, and consumption responses



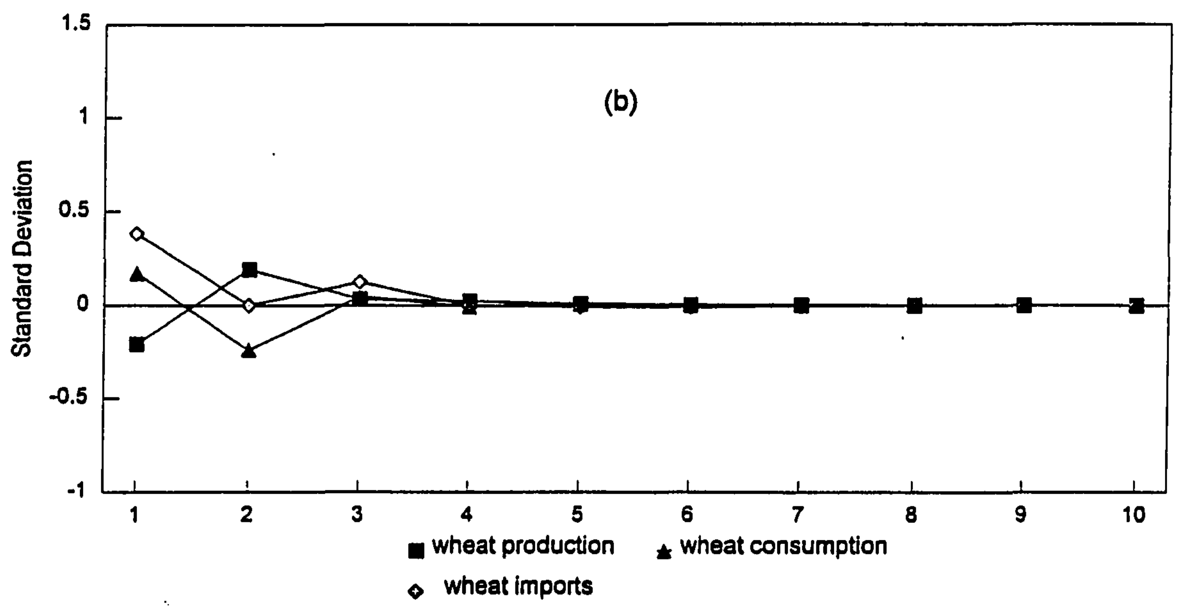
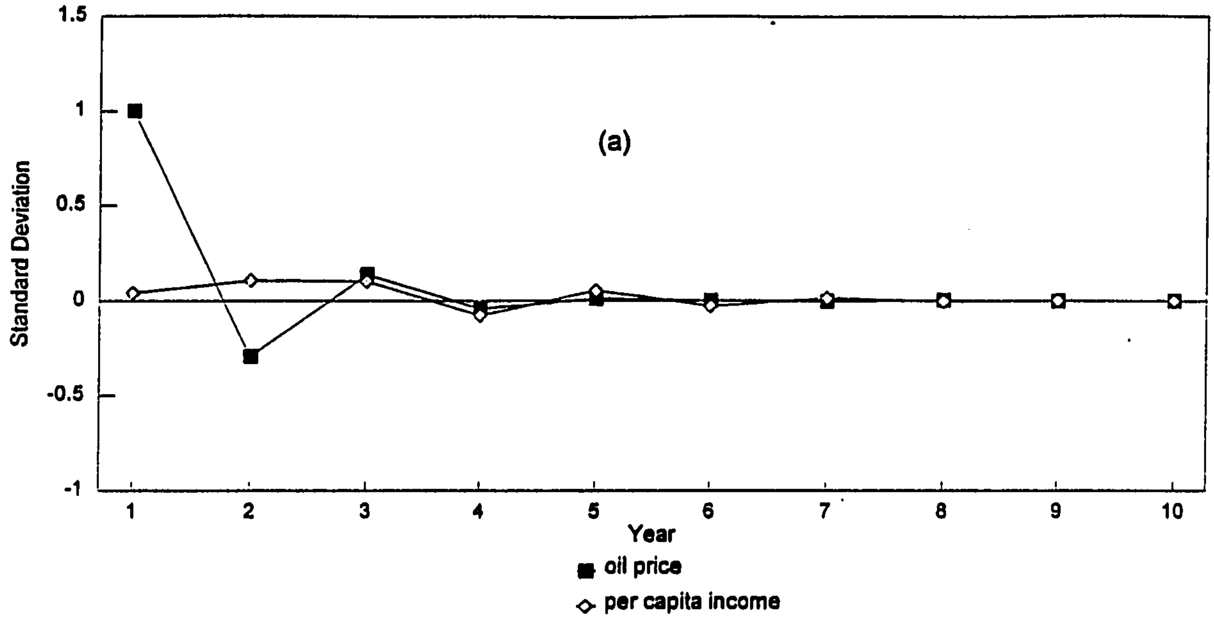


Figure 4.2. Responses to an oil price shock in Iran

(a) oil price and per capita income responses
(b) wheat production, wheat imports, and consumption responses



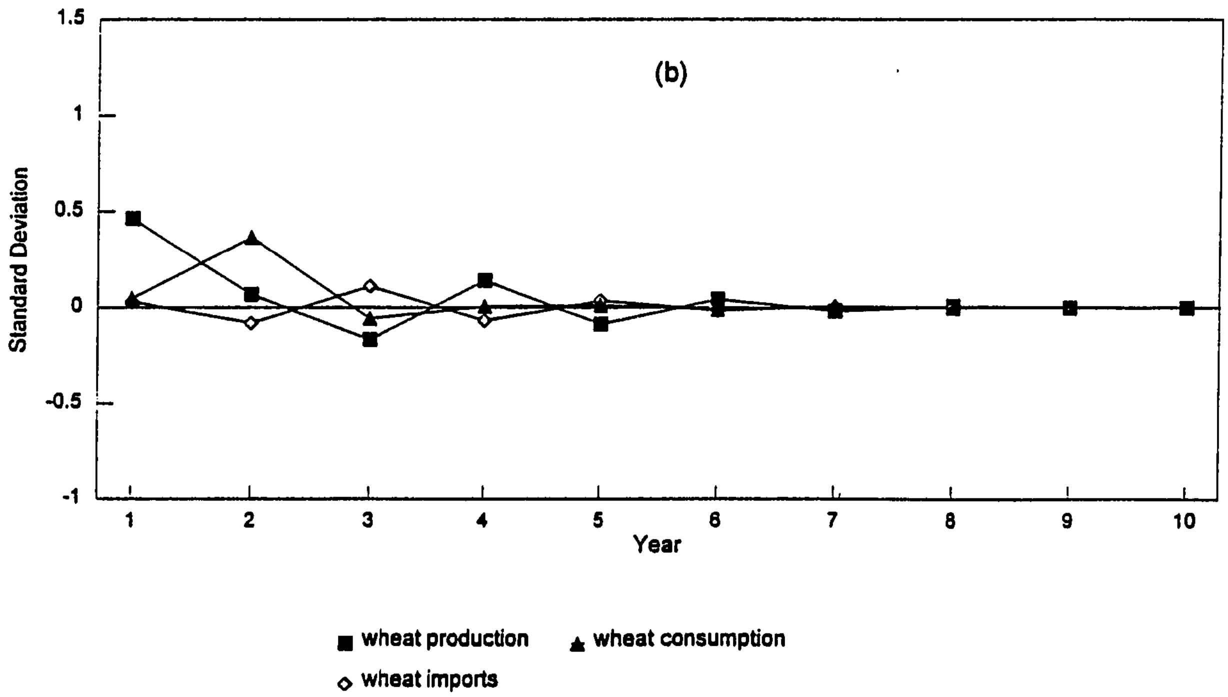


Figure 4.3. Responses to an oil shock in Saudi Arabia

(a) oil price and per capita income responses
(b) wheat production, wheat imports, and consumption responses

CHAPTER V. OIL PRICE AND AGRICULTURAL POLICY: IRANIAN CASE

Iran, with an area of 1,468,195 square kilometers, has a total farmland area of 17 million hectares (20% of the country) of which about 32 percent or 5.5 million hectares is not cultivated. Of the 11.5 million hectares under cultivation, about 50 percent or 5.6 million hectares are irrigated, including one million hectares in orchards (Kavossi, 1991). Given climate constraints, agricultural policies in Iran are important economically and politically in the economic development of the country. The agricultural sector (a) employs a large portion of the population and (b) is an important source of food for the people. As mentioned in chapter 3, the objectives of agricultural policies after the Islamic Revolution in 1979 was to increase output, improve productivity and achieve food self-sufficiency. These are different from pre-revolution objectives not only in direction but also in means.

After 1979, the agricultural sector of Iran--in spite of remarkable increases in the use of inputs, such as fertilizers and farm machinery, and emphasis by the government on self- sufficiency (especially in wheat, Table 5.1)--experienced disappointing performance. The average annual growth rate in agriculture for 1965-80 and 1980-90 were 4.5 and 4.0 percent, respectively. Also, the population

Table 5.1. Government subsidy by commodities (Iran) [1980/81-1989/90]
(in billions of Iranian rials)

Year	1980/81	1981/82	1982/83	983/84	1984/85	1985/86	1986/87	1987/88	1988/89
Fertilizer	14.6	20.0	27.0	25.3	27.8	22.0	20.5	19.0	18.3
Wheat	3.7	24.0	37.0	24.3	27.0	51.0	68.3	40.2	39.0

Source: The Ministry of Economy and Finance, Iran (1990).

growth rate for those periods were 3.2 and 3.4, respectively (World Bank Report, 1987 and 1992). Iran is not an exception in the region for the poor performance in agricultural policies. Rapidly escalating food demand and sluggish supply response in Middle East and North Africa countries have made the area one of the least food self-sufficient region in the world. The emergence of this "food gap" does not mean (as some have implied) that agricultural supply has stagnated, although this has happened in some cases. Rather, it means the measures taken to reduce the inequality between the rate of growth of demand and domestic supply and to restore food self-sufficiency have fallen short (Richards and Waterbury, 1990) (see Table 5.2).

In searching for the causes of this "food gap" in Iran, we select wheat as a strategic agricultural product and as a proxy for food to analyze pricing policy and to explore the incentive role of producer prices in the wheat production-consumption gap. A major point of contention in the agricultural policy debate in Iran centers on the influence of oil prices on food production, consumption, imports,and self-sufficiency in food. On the one hand, it is argued that increases in oil prices lead to increase in food imports, which in turn causes an adverse impact on domestic production. Others, however, argue that shortfalls in domestic production, independent of oil price changes, are the cause of the increasing trend in food imports. In section two of this chapter, the empirical evidence for the direction of causality and dynamic linkages between variables influencing the wheat

Table 5.2. Characteristics of grain imports and production, and food self-sufficiency

Oil Exporting Countries	1966-80 growth in		1981-85 growth in		Self-sufficiency ratio			
	Imports	Production	Imports	Production	1970	1975	1980	1985
	Percent per year				Percent			
Algeria	13.1	1.5	7.6	-8.3	77.0	79.0	48.0	45.0
Egypt	2.7	1.5	9.2	2.2	79.0	59.0	49.0	42.0
Iran	8.3	1.8	1.3	0.1	90.0	79.0	65.0	59.0
Iraq	20.8	-2.2	9.8	- 2.3	89.0	52.0	44.0	28.0
Saudi A.	14.1	-3.6	8.9	48.5	46.0	25.0	7.0	28(a)
Syria	8.7	6.7	7.0	- 5.9	54.0	97.0	107.0	66.0
Tunisia	6.5	7.1	-7.4	12.9	56.0	78.0	54.0	85.0

(a) Saudi Arabia was self-sufficent in wheat by 1984.

Source: Shapouri and Rosen, 1986.

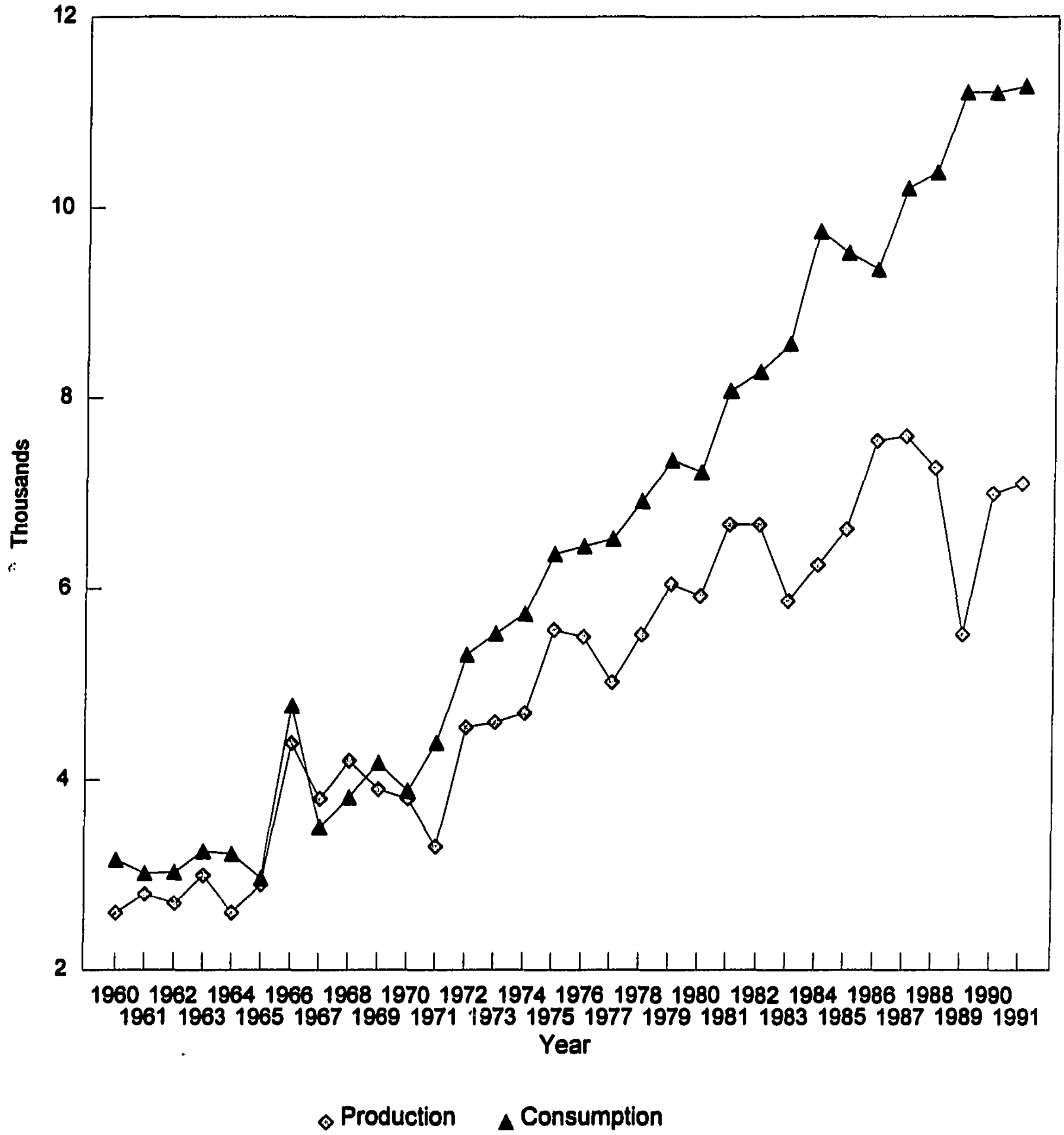


Figure 5.1. Production-consumption gap of wheat in Iran

consumption-production gap are examined.

Oil Prices and Wheat Gap

To analyze the implication of the " Oil Shocks", in the wheat sector, we examine the domestic supply and demand and then turn to the consequences of the resulting escalating of wheat imports. As mentioned in chapter III, after the first "oil shock" in 1973-74, the Iranian government relied on oil revenue to finance agricultural imports and the share of agriculture in total government investment was reduced. In 1974, Iran produced 4,600 thousand tons of wheat and imported 789 thousand tons. This wheat consumption-production gap was party due to the Shah's land reform program, and was expected. This gap continued to widen and was mostly met through an increse in imports. (see Fig. 5.1)

There are two ways to increase agricultural production: (1) increase planted area, in other words bring new land into cultivation, and (2) raise the productivity of the existing planted area. Increasing yields have played an important role in expanding the domestic supply of wheat in Iran and the entire region. For the two decades of the 1970s and 1980s in the Middle East and North Africa, some 55 percent of the growth in food output was the result of increased yields, whereas, extension of cultivated area explains the remaining 45 percent. During the era of oil boom (1973-1980), some 88 percent of output growth was caused by higher yields (Khaldi, 1984).

In Iran, wheat production had an upward trend (except for 1978 and 1981), in spite of a decrease in area under wheat production from 6325 hectares in 1974 to 6192 hectares in 1983. This inverse trend indicates that the decrease in area was more than compensated by the increase in yield from 727 kg per hectare in 1974 to 1076 kg per hectare in 1983. The increase in yield was partly due to the use of improved seed and fertilizer which were made available to the farmers at subsidized prices largely financed by oil revenues. In the 1974-1991 period, wheat production in Iran increased from 4700 thousand tons to 8315 thousand tons. As Table 5.3 reports, wheat production, which had been steadily growing before the Revolution, has experienced some fluctuation since 1979, mainly due to severe drought in 1979-80 and 1983, and to unusually favorable weather condition in 1985-1986. From the food security point of view, the variation of agricultural production in general, and cereal production in particular, was high during oil shock periods, i.e., 1973-1985. The average growth rate for cereal was 3.71, and standard deviation was 10.98. In per capita terms they were .67 and 10.67, respectively. The wheat production in the 1987-1991 period showed remarkable growth rates (except for 1989/90), but with accompanying high fluctuation due to scant rainfall in many parts of the country during the late 1980s. In the same period, despite the limited availability of cultivable land, the area under foodgrains production, of which 73 percent is devoted to wheat, increased by about 2.5 percent annually. In addition,

Table 5.3. Iran wheat production, consumption, and imports

Year	Production (1000 mt)	Consumption (1000 mt)	Per Capita consumption (Kg)	Imports (1000 mt)
1974	4700	5750	180.0	1452
1975	5500	5790	176.4	1466
1976	5965	5349	158.7	737
1977	5500	5926	168.5	1159
1978	5526	5926	162.8	730
1979	5946	5884	155.6	400
1980	5744	6148	156.5	871
1981	6610	7131	174.7	1615
1982	6660	8162	192.4	1769
1983	5956	7878	178.8	2683
1984	6706	7533	164.4	2618
1985	6630	8276	173.8	2144
1986	7577	8482	171.6	1831
1987	7600	11031	200.8	3712
1988	7265	10715	200.2	3423
1989	5511	10610	199.7	5312
1990	7000	11750	200.0	4818
1991	8315	12746	200.0	4521

Source: Ministry of Agriculture (Iran). Extracted from Haqverdi (Farsi).
The data for period 1989-1991 obtained from FAO sources.

more resources were allocated to agriculture after the Iran-Iraq war. And other institutional factors, such as incentives provided through producer price policy, also may have contributed to this upward trend in wheat production in the most recent period. Indeed, the growth of agricultural output in Middle East countries is better than that of some other developing countries. But the point is that the agriculture sector still lags behind in relation to the growth in the demand for agricultural products. In other words, the problem in the region is not of stagnation or declining output, as is often the case in other developing countries, rather a demand growth that exceeds the supply growth.

All of the estimates of food demand-supply balance in the region agree that demand will continue to grow rapidly (see e.g., FAO, and Khaldi). On the demand side, Khaldi found that total annual staples consumption grew at 4.8 percent from 1973 to 1980; while the rate for oil-exporting countries in the region was 6.2 percent per year. Among others, there are three major determinants of demand growth: population growth, per capita income growth, and the income elasticity of demand. Due to data limitation for individual countries, we focus our analysis on food consumption of oil exporting countries in the region. Apart from sub-Sahara Africa, the Middle East and North Africa countries have the highest rate of population growth of any region in the world. Rapid population growth did make a substantial contribution to increased demand for food. However, much of the growth in demand has been caused by expansion of per capita incomes (Richards,

1987) (see Table 5.4). The population effect was compounded during the decade of oil boom by the rapid growth of income. Even for cereals for direct food consumption in the region, income growth accounted for roughly 25 percent of the growth of consumption. Cereal demand as a whole grew much more rapidly, largely as a result of soaring demand for feeding animals. The changing composition of diets in the region came from the expansion of incomes resulting from the oil boom. Based on structural changes in consumption of food and some political consideration, there is some evidence (Shapouri and Rosen, 1986 and Gardner, 1986) that food consumption in oil exporting countries in the region, continues to increase despite a decline in income. So there is unlikely to be any reduction in the food consumption-production gap, at least in short run, from the demand side. Wheat consumption in Iran increased from 5750 thousand tons in 1974/5 to 12746 thousand tons in 1991/2. Even after a decline in oil prices starting in 1986 the consumption trend continued in the upward direction.

The first response to this food production-consumption gap by governments was to increase food imports. For two decades, 1960-1980, the region's food import increased about 12% per year. There were four economic reasons for the import boom in the region. First, as mentioned earlier, domestic production was (and is) highly unstable because of erratic rainfall. Second, the barter terms of trade moved sharply in favor of oil exporters/food importers. In 1970 a barrel of oil would buy roughly one bushel of wheat; by 1980 the same barrel could buy six

Table 5.4. Source of growth of consumption of food, by commodity group in the oil exporting in MENA

A: Staples		For Food		For Feed		All Uses	
		g	% y	g	% y	g	% y
	Region	3.6	25	6.8	60	4.8	44
	Oil Exp.	5.1	39	9.4	67	6.2	50
B: Cereal							
	Region	3.6	25	6.9	61	4.9	45
	Oil Exp.	5.1	39	9.4	67	6.2	52
C: Animal Products		Total		Chicken		Milk	
		g	% y	g	% y	g	% y
	Region	6.8	60	14.0	81	5.1	47
	Oil Exp.	12.7	76	20.8	85	9.3	66

g = growth of consumption
% y = percent of growth of consumption caused by income growth,using the formula g = n + y e, where n = poplation growth rate , and e = income elasticity of demand.
Oil Exp. are: Algeria, Iran, Iraq, Kuwait, libya, Oman, and Saudi Arabia
Population growth rate in Oil Exp. =3.1 percent.
Source: Richards and Khaldi

bushels. Even in 1986, after the drop in oil prices, a barrel of oil was worth three bushels of wheat. Third, most MENA countries had ample supplies of foreign exchange, in other words, the balance of payments did not constrain food imports in 1970s. The 1980s are another matter. Fourth, since most wheat importers in the region are small relative to the size of the international market, increased purchases have no impact on world prices. Finally, in some countries urban-consumer tastes shifted away from local grains toward bread wheat, whose production was sometimes locally difficult (Richards and Waterbury, 1990).

In all countries in the region increases in export earnings and/or credit led to increased imports of agricultural products during the 1970's. After 1980, the story begins to change. The annual rate of increase in export earnings in Algeria, Iran, and Saudi Arabia, for example, decreased from 21.0, 20.4, and 31.1, in 1966-80 period to -1.9, 1.6, and - 28.8 in 1981-85 period, respectively. Total imports declined almost 2 percent annually during 1981-85, while food imports continued to increase but at a slower rate than previously (4% per year). According to Shapouri and Rosen (1986) four primary reasons account for this trend:

(1) Variation in Export Earning

(2) Growth in Credit

(3) Government Policies

(4) Slow Production Growth

They found, among other things, that import capacity was the most significant variable in explaining the level of food imports , and in turn, it depends on export earnings and the availability of credit. They also found that cereal imports have become a significant contributor to the overall levels of availability.

In the case of Iran, the increasing dependency on food imports over domestic production in meeting food demand can be traced back to the influence of oil revenues in agricultural and food policy. The relationship between changes in oil export earnings and agricultural imports during 1970's and 1980's was analyzed by the Department of Agriculture in the United States for the period 1969-1988 for selected oil exporting countries. The result is reported in Table 5.5. For Iran, a one percent increase (decrease) in the price of oil implies a 0.889 percent increase (decrease) in agricultural imports. Also, the study indicated that changes in the price of crude oil alone accounted for about 90 percent of the change in value of agricultural imports for all the countries in the study. This strong link between agricultural imports and oil price suggests the proclivity of oil exporting countries to satisfy their domestic food demand more with imports rather than domestic production. Consequently, the need to expand agricultural production is significantly reduced. Moreover, in the case of Iran, the government was under no political pressure from established large landlords to provide facility to increase agricultural production. The oil revenues allowed the government to defuse the power of landlords by purchasing their land for redistribution to landless farmers under a land reform program of the 1960s (Shafaeddin, 1988). Fig.5.2 shows the

Table 5.5. Elasticity of agricultural imports with respect to nominal oil prices

Country	Elasticity	R^2
Algeria	0.827*	0.95
Indonesia	0.552*	0.89
Iran	0.889*	0.94
Iraq	0.968*	0.94
Mexico	0.824*	0.89
Nigeria	0.846*	0.87
Saudi Arabia	1.011*	0.89
Venezuela	0.673*	0.92

* Denotes statistical significance at a $p < 0.01$.
Source: USDA (1986).

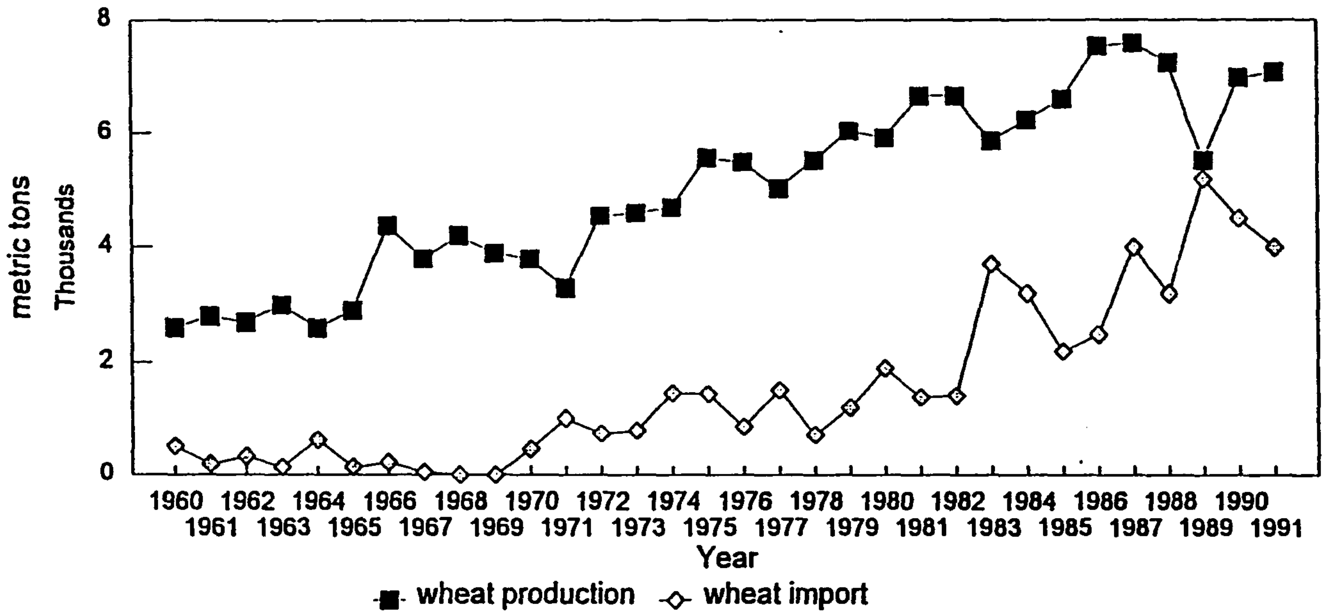


Figure 5.2. Wheat production and import in Iran

trend and fluctuations of wheat production and imports for three decades, 1960-1991, in Iran.

However, this response of the government to the imbalances in food supply and demand can not be sustained over a prolonged period of time. The variability in oil revenues presents a major challenge to policy makers in managing the food supply (domestic production + imports) in the country (e.g., the oil revenue in Iran in 1990 was 10.6% larger than targeted, and was 14.4, 9.1, and 20.6 less than targeted for 1989, 1991 and 1992, respectively). An even more serious problem is the possibility of foreign exchange constraints in the future. Furthermore, too much dependency on foreign suppliers for basic commodities like food may subject the country to food embargo for political reasons. For these economic and political considerations, the government of Iran attempted other alternatives to reduce or ultimately eliminate the food production-consumption gap by intervening in the agriculture sector both to boost and stabilize production. The major form of intervention included (a) direct investment in agriculture (discussed in Chapter III), and (b) pricing policies intended to provided incentives for production.

Agricultural Price Policy in Iran: Wheat Case

The government intervention in agricultural price policies has a long history in MENA. For example, wheat and barely prices controls by the government in Iran started in 1916. The aim of the intervention was to prevent severe fluctuation in the prices of these commodities in the interest of the city dwellers. In fact, like many developing countries, price policies in Iran were consumer-oriented until recently. Some governments have impeded the growth of output of cereals through their output pricing policies. Indeed, some believe that this is the cause of the food gap. The argument holds that if only government could "get the prices right"--specifically, permit cereal prices to rise to world level--the food gap would shrink dramatically (Richards, 1987). But, finding the "right" producer price (i.e., the price that is high enough to encourage production) and the "right" consumer price (i.e., the price that is low enough or "not too high" to keep consumers happy) is a difficult challenge. For one, the government has to balance conflicting objectives and interests (Tapsolra, 1990), and the informational requirements are tremendous. The actual result of the pricing polices in Iran indicate some bias towards the consumer at the expense of turning the terms of trade against agriculture, i.e., agricultural products are sold for a fixed price that is determined by the government while the price of non-agricultural goods are determined in the market and are free to rise in response to market forces. A study by Shafaeddin (1988) for the 1965-77 period, indicates that the terms of trade deteriorated against wheat and this deterioration was exacerbated by government wheat trade polices. For instance, whenever the wholesale wheat price (WPIW) tended to decline, as in 1966 - 68, due to a good harvest, the government did not make any attempt to support it by increasing its purchase. Ironically, it even exacerbated the situation in some period by increasing supply, mainly from subsidized wheat imports. In contrast, whenever the wholesale price tended to rise, such as in 1963-65 and 1972-1974, it supplied wheat to the market in relatively large quantities (see Table 5.6), causing the wheat price to increase less than it would have otherwise. Also, it can seen from Table 5.6, the increase in the official sale price has been sluggish compared to the wholesale price of wheat (WPIW), that the government's sale price rose 30% against 100% for the WPIW, from 1959 to 1977. When considering the importance of the government sale in relation to production, the government sale policy (unlike its purchase policy) have had significant dampening effect on the wholesale price. Wheat purchaseed by the government as a percentage of total production in 1974 reached to only 2.5%, but the net government sale repesented a bigger share in relation to wheat consumption, 22 percent in 1974. The wholesale price of wheat is constructed on the basis of prices generated in the private trading of wheat (representing the part of demand not satisfied by government's sale).

The nominal protection coefficient (NPCs)[(1)] is often used to show the degree of producer price support by government. In the MENA region only four countries (including two oil-exporting countries) had a wheat NPC greater than one in the 1971-1981 period, Table 5.7. Specifically, in the late 1976 in Iran, farmers received around 10 rials a kilogram for wheat, an amount mildly regarded as adequate to cover the cost of cultivation. At the same time the government was paying 18 rials a kilogram for imported wheat (Looney, 1983). Also, the prices set

Table 5.6. Data on wheat domestic puchase and sale by Iranian government (1955-1977)

Year	Purchase (1000 tons)	Sale	Official prices (rial/tons) purchase	sale	wholesale pric index of wheat (WPIW)
1959	36.5	162.5	5000	6200	100.0
1960	12.2	177.7	5000	6200	105.8
1961	127.4	263.5	5000	6200	105.4
1962	56.0	201.7	5000	6200	113.2
1963	133.9	161.7	5000	6200	103.9
1964	7.1	257.7	5000	7510	121.9
1965	15.5	334.0	5000	7510	130.8
1966	197.2	241.9	5000	7510	114.6
1967	246.3	400.0	5000	7510	93.0
1968	244.7	53.3	5500	7500	86.5
1969	9.3	101.6	5500	6730	101.1
1970	3.7	310.6	5500	7510	122.2
1971	0.8	804.4	5500	7510	138.4
1972	5.0	524.8	6300	7510	118.5
1973	3.1	593.7	6500	7510	127.1
1974	116.2	1370.8	8000	7510	204.1
1975	496.7	1553.8	9000 -10000	7510	166.9
1976	793.9	1641.8	9000 -10625	7510	171.4
1977	980.5	2000.0	11000-12000	8008	200.9

Source: Shafaeddin (1988).

Table 5.7. Currency overvaluation and average producer Prices for wheat (1971-1981)

Country	Index of Currency Overvaluation	Average Producer Official Exchange Rate	Price of Wheat Using Market Exchange Rate
Algeria	178	127	71
Egypt	174	79	45
Iran	120	110	92
Iraq	118	88	74
Jordan	101	102	101
Libya	143	165	115
Morocco	104	141	136
Saudi A.	99	235	237
Sudan	181	137	76
Syria	107	93	87
Tunisia	115	103	90
Turkey	125	91	73

Source: Richards and Waterbury, 1990.

by the government did not reflect the higher prices of factors of production such as fertilizer and machinery. For example, between 1970 and 1977, the price of fertilizer rose by about 28 percent and that of tractors by 51 percent (Central Bank, 1978).

After the Islamic Revolution in Iran, the government's setting of the price of wheat was the most important ingredient of its agricultural price policy. The objectives of wheat pricing were to encourage production by increasing the producer price on the one hand, and to subsidize bread for urban population on the other hand. It is expected that this policy will help country to achieve self-sufficiency in wheat for food and national security goals.

As in many other countries, the Iranian government's control over agricultural prices is partial and lopsided. At one extreme for example, wheat price is effectively controlled by the government while, at other extreme, fruit and vegetable (e.g., watermelon) prices are left to market forces. This structure in government pricing and the presence of inflation has led to wheat prices lagging behind other prices. Therefore, not only has agricultural profitability declined, but also the relative prices (internal terms of trade) within agriculture have turned against staple food grains. This may lead to more variation or decline in the domestic grains production.

The governments in food-deficit developing countries, in general, in case of a decline in foreign exchange reserve and/or possible log-run instability of export earnings and presence of inflation, may be forced to raise the administered prices of grains (wheat) to offset increases in farm production cost and to restore production incentives and stabilize domestic production. However, more often than not, inflation quickly erodes the incentives, and the cycle repeats itself again.

This cycle in grain pricing policy can be clearly seen in the case of wheat prices in Iran. Before the Revolution, particularly after the first "oil shock" in 1974, when wheat imports almost doubled, the government increased the price of wheat substantially. But since the price was kept constant for the next two years despite high inflation rates, the real price of wheat declined sharply. Then the imports which had decreased in 1976 began to rise again in 1977. In response, the government increased prices by about 20 percent, but this was too little, too late, and real price of wheat continued to decline. After the Revolution, the price of wheat was raised again, but the increases could not match the ongoing inflation. So, by 1980, the relative price of wheat was falling and imports were rising. In 1981 and 1983, the price of wheat was increased by 40 and 30 percent, respectively, quickly restoring profitability in producing wheat, but each time the price increase was followed by an effective price freeze, so that relative gains were quickly lost to inflation (Mojtahed and Esfahani, 1989). The relative price index in Table 5.8 indicates that the price of wheat has been particularly lagging behind other agricultural prices. To provide adequate incentives it is vital for the price policy in Iran not only to avoid the stop-and-go scheme, but also consider the

Table 5.8. Farmgate price of wheat offered by the government

Year	Farmgate nominal price of wheat (rials/kg)	Index of price of wheat relative to : Consumer prices	Wholesale prices
1973	5.5	63.3	n.a.
1974	10.0	100.0	100.0
1975	10.0	91.0	98.1
1976	10.0	78.2	79.7
1977	12.0	75.0	82.2
1978	14.0	79.3	81.9
1979	18.0	91.6	80.0
1980	20.0	82.1	61.6
1981	28.0	94.0	72.5
1982	30.0	84.5	68.5
1983	40.0	95.7	76.5
1984	40.0	86.6	62.0
1985	40.0	83.2	57.1
1986	46.0	79.5	n.a.
1987	48(a)	n.a.	n.a.

(a) In 1987, in addition to the price of 48 rials per kilogram, in-kind " prizes" were also offered to farmers for delivering their wheat to the government.
Source: Mojtahed and Esfahani, 1989.

profitability of production. For example, under two different methods of wheat production, i.e. semi-mechanization and traditional, the yield and production cost in these two methods are different. Therefore, in 1984 when administered price of wheat was 30 rials the traditional producer lost 2 rials per kilogram, while other producers made 9 rials profit.

Finally, two factors play important roles in recent years in wheat production: (a) increasing price continuously (e.g., official wheat price was 53.0, 57.0, 100.0, 150.0 and 225.0 rials per kilogram in 1988, 1989, 1990, 1991, and 1992, respectively), and (2) reforming in price policy system from fixing price to guarantee price (government guarantee to purchase wheat and some other agricultural products at prices announced each year).

In comparing the performance of price policies in pre-revolution and post-revolution in Iran, Mojtahed and Esfahani indicate that after the revolution, the overall terms of trade have turned in favor of agriculture. However, this type grains price polices, is probably the main reason that cereal production has fluctuated much more than the total crops production in recent years. Moreover, Richards mentioned, that domestic production fluctuations, not price instability, is the main source of food insecurity both globally and in MENA region.

Oil Price, Wheat Production, and Wheat Imports in Iran: a Causality Analysis

According to the Food and Agriculture Organization (FAO), "food security has three specific aims: ensuring production of adequate food supplies, maximizing stability in the supplies, and securing access to available supply on the part of those who need them." Internal and external factors influence food availability and, thus, food security at the national and regional level. In this chapter we consider and test the relationship between two important components of food security, wheat production and imports, and the price of oil, which plays a vital role in all major oil exporting counties.

Formal investigation of causal relationships of variables impacting food security is necessary for policy purposes. Causal relationship can not be determined from standard statistical methods. For example, finding a high correlation among variables does not necessarily imply the presence of a causal linkage among them. It can be spurious--that is, their correlation may actually be due to a third factor. On the other hand, functionally (in a non-linear fashion) related variables may be uncorrelated (a linear measure of functional relationship). Hence, it is the primary goal of this section to explore the causal relationship between wheat imports, as a important component in food availability, and wheat domestic production and oil prices in Iran.

The method employed for analyzing causal relationship is based on the concept of "Granger Causality", developed by Granger (1969) in his seminal paper entitled "Investigating Causal Relations". The idea is: a time series process X "causes" another time series Y if, by incorporating the past history of X, one can improve a prediction of Y compared to a prediction based on the history of Y alone.

This notion of causality has spawned a vast and influential literature. For example, macro economic studies of Granger causality have included investigation of the causal relationships between money and income, between wages and prices (see Feige and Pearce for a review of these studies), and between GNP and energy consumption (see, for instance, Abosedra and Baghestani, 1991). An example of causality investigation in agricultural economics is "Chickens, Eggs, and Causality " (Thurman and Fisher, 1988).

Since "cause" is a loaded term, to avoid misunderstanding some people use other terms such as "precedent" as suggested by Leamer (Maddala, 1988), and interpret the Granger Causality as meaning knowledge of X (t) increase one's ability to forecast Y(t+1) in a least squares sense (Conway et al., 1984). About ten years after his initial paper, Granger introduced a distinguishing title for his definition and concept of "causality", which is quite different from the general use and logically correct, from alternative terms, by suggesting that be called "Granger

Causality" (Granger, 1980).

Assessments of "Granger Causality" have both practical and theoretical value (Freeman, 1982). Indeed, in economics, tests for this kind of causality are becoming recognized as essential steps in building a model (Sargent, 1981).

Operationalization and testing

For a bivariate case, consider a jointly stationary processes X and Y. Let all past values of X_t and Y_t be denoted by x^,y^ and all past and present values of X_t and Y_t be represented as x^^and y^^. Also, define σ^2 as minimum prediction variance(2). There are number of ways to define causality. Four of the most popular cases are presented below:

I Y Causes X : $\sigma^2 (X_t \mid \hat{y}_t, \hat{x}_t) < \sigma^2 (X_t \mid \hat{x}_t)$

II Y Causes X instantaneously : $\sigma^2 (X_t \mid \hat{\hat{y}}_t, \hat{x}_t) < \sigma^2 (X_t \mid \hat{y}_t, \hat{x}_t)$

III Feed Back : Y Causes X and X Causes Y.

IV Independence : $\sigma^2 (X_t \mid \hat{y}_t, \hat{x}_t) = \sigma^2 (X_t \mid \hat{x}_t) = \sigma^2 (X_t \mid \hat{\hat{y}}_t, \hat{x}_t)$
and
$\sigma^2 (Y_t \mid \hat{y}_t, \hat{x}_t) = \sigma^2 (Y_t \mid \hat{y}_t) = \sigma^2 (Y_t \mid \hat{\hat{x}}_t, \hat{y}_t)$

Three tests of causality have been proposed within Granger's definition of causality: (i) the Direct-Granger test which is based on his definition and applied as a one-sided distributed lag, (ii) the Sims (1972) approach based on a two-sided distributed lag, and (iii) a cross-correlation between the residual series method suggested by Pierce and Haugh (1977).

The Granger and Sims tests are theoretically equivalent (Doan,1992), and as Freeman pointed out, the Pierce-Haugh technique is really a test for independence only. The properties of variants of these three tests of causal direction have been studied by, for instance, Geweke, Meese, and Dent. All studies indicate the Direct-Granger test is preferable to the Sims and Pierce-Haugh tests of causality (Abosedra and Baghestani, 1991).

Among the problems associated with the Direct-Granger method, however, is the need to choose a sufficient lag length for the right side of the autoregressive representations of a bivariate system:

$$Y_t = \Sigma_1^m \alpha_i Y_{t-i} + \Sigma_1^n \beta_j X_{t-j} + \epsilon_{1t} \tag{5. 1}$$

$$X_t = \Sigma_1^m \lambda_i Y_{t-i} + \Sigma_1^n \delta_j X_{t-j} + \varepsilon_{2t} \tag{5. 2}$$

If an insufficient number of lags is chosen, there is likely to be serial correlation in the residuals and therefore, a biased hypothesis test (Feige and Pearce, 1979). Another difficulty with this technique is that estimated residual in the test equations (5. 1)and (5. 2) are assumed to be independent. If this is not the case and ϵ_{1t} and ϵ_{2t} are contemporaneously correlated, the Zellner-Aitken generalized least squares regression estimating simultaneously these two equations provides results that are similar to those of the Direct-Granger method (Cuddington, 1980).

Empirical evidence

To use the standard Direct-Granger causality test we specify a set of two unrestricted equations. We explore the causal linkage between oil price (OP), and wheat imports (M) by using equations (5. 3) and (5. 4). On the other hand, equations (5. 5) and (5. 6) are used to detect the causality relation between domestic wheat production (Q) and wheat imports (M).

$$M_t=\Sigma_1^m \alpha_i M_{t-i}+\Sigma_1^n \beta_j OP_{t-j}+\varepsilon_{1t} \tag{5. 3}$$

$$OP_t=\Sigma_1^m \lambda_i OP_{t-i}+\Sigma_1^n \delta_j M_{t-j}+\varepsilon_{2t} \tag{5. 4}$$

$$M_t=\Sigma_1^m \alpha_i M_{t-i}+\Sigma_1^n \beta_j Q_{t-j}+\mu_{it} \tag{5. 5}$$

$$Q_t=\Sigma_1^m \lambda_i Q_{t-i}+\Sigma_1^n \delta_j M_{t-j}+\mu_{2t} \tag{5. 6}$$

To test for stationarity of these four time series we applied a Dicky-Fuller test. The results indicate that only domestic production of wheat (Q) is a stationary process. To eliminate the problem of time series serial correlation and "spurious regression" all three non stationary processes are transformed into first-order difference form. We use the domestic production level of wheat, both with and without a time trend.

We applied these unrestricted equations to Granger causality test for the two pairs of variables mentioned above for Iran covering the period 1964-1991. Since our data are annual, such test equations might be misspecified if there is a significant causal relationship with a lag length of less than one year between the variables. To overcome this possible problem, it is more appropriate to use the Direct-Granger test in the form suggested by Feige and Johannes; that is, we add the current value of independent variable in right side of test equations (run for j>0).

The null hypothesis that oil price (OP) does not cause wheat imports (M), is tested by examining the joint significance of the coefficients on *n* past OP in equation (5. 3). To test of OP does not cause (M) "at all" (i.e., including contemporaneously), we examine the joint significance of coefficients on OP and *n* past OP in equation (5. 3). To test whether "wheat import does not cause oil price" we use equation (5. 4) in the same manner. A lag length of 2 for independent variables is chosen (n =2) for equation (5. 4). This is deemed adequate since annual data are used, and to ensure enough degrees of freedom for better precision of estimates. However, in Tables 5.10 and 5.11 since Q needed no differencing, the lag length can be increased up to 3 to accomodate more dynamics in the model (different lag lenghts were tested, but not reported here).

Table (5.9) reports the calculated F-value for (i) OP (M) does not cause M (OP), (ii) OP (M) does not cause M (OP) "at all". Note that F(A) refers to the F-statistics for the "at all" causality test (i.e., when considering both the lagged and the contemporaneous variables), and F(S) refers to strict causality test, that is when

Table 5.9. Granger-causality F-test

Causality: from oil price to wheat import

no. of lag in ind. variables	null hypothesis	F(A)[a]	F(S)[a]	$\bar{R}^2$	D-h / t[b]
[1]	OP not cause M	3.28 (2, 23)**	4.40 (1, 24)*	.23	1.08/ -
[2]	OP not cause M	2.24 (3, 21)[c]	2.71(2, 22)**	.21	NC / 1.82[d]

Causality: from wheat import to oil price

no. of lag in ind. variables	null hypothesis	F(A)[a]	F(S)[a]	$\bar{R}^2$	D-h / t[b]
[1]	M not cause OP	1.50 (2, 23)	.98 (1, 24)	.03	NC / .53
[2]	M not cause OP	.91 (3, 21)	.58 (2, 22)	.07	NC / .78

[a] F(A) refers to the causality F- statistics for the " at all " causality and F(S) refers to the strict causality test. Degrees of freedom are given in parantheses.

[b] Adjusted R-squared and D-h (Durbin- h) and t-values are from the unrestricted test equations.

[c] F- critical value at 10% level is 2.36.

[d] NC indicates that the Durbin- h statistic can not computed.

* Significant at 5-percent level.

** Significant at 10- percent level.

one just considers the lagged variables.

An examination of F(A) and F(S) in the first panel in Table (5.9) indicates the presence of a unidirectional causality from oil price to wheat imports (OP $\Rightarrow$ M). in other words, the "past and current " history and also "past" history of oil price help predict wheat imports in Iran. The latter appears to have a more stronger causal linkage than the former. Examination of the second panel suggests no causation between oil price and wheat imports, when the "past and present" information is considered, but there is a unidirectional causal relation from oil price to wheat imports when we consider "past" information of oil price only.

The results of the Direct-Granger test, relating wheat domestic production (with time trend) and wheat imports for alternative lag lengths, are summarized in Table (5.10). These results suggest the presence of strong causality linkage from wheat production to wheat imports when both the contemporaneous and lag variables are considered. Examination of F(S), however, suggests no causation between the two variables, for all different lag structures. The current effect from Q to M seems to be significant in all cases. The structure of Table (5.10) is the same as Table (5.11), except the level of Q is detrended(3).

Again, the examination of F(A) indicates the presence of a strong bidirectional (feed back) causality from Q to M. In comparing Table (5.10) and (5.11), on the basis of the "F-statistic" values, the effects from domestic production of wheat to wheat imports appear to be more pronounced than when we use

Table 5.10. Direct - Granger F-Test : Domestic wheat production process with time trend

Causality: from wheat production to wheat import

no. of lag in ind. variables	null hypothesis	F(A)[a]	F(S)[a]	$\bar{R}^2$	D-h /t[b]
[2]	[Q not causeM]	5.04 (3, 20)**	2.14 (2, 21)	.51	-1.2/ -
[3]	[Q not causeM]	4.44 (4, 17) *	1.60 (3, 18)	.53	NC/ 1.14

Causality: from wheat import to wheat production

no. of lag in ind. variables	null hypothesis	F(A)[a]	F(S)[a]	$\bar{R}^2$	D-h /t[b]
[2]	[M not causeQ]	3.40 (3, 20)	.37(2, 21)	.78	NC / .14
[3]	[M not causeQ]	3.16 (4, 17)**	.47(3, 18)	.70	NC / .59

*Significant at 5 - percent level
** Significant at 1- percent level

Table 5.11. Direct - Granger F-Test: Domestic wheat production process without time trend

Causality: from wheat production to wheat import

no. of lag in ind. variables	null hypothesis	F(A)[a]	F(S)[a]	$\bar{R}^2$	D-h /t[b]
[2]	[Q not cause M]	4.62 (3, 20)*	1.72 (2, 21)	.49	NC /0.19
[3]	[Q not cause M]	3.52 (4, 17)*	.99 (3, 18)	.48	NC / 2.17

Causality: from wheat import to wheat production

no. of lag in ind. variables	null hypothesis	F(A)[a]	F(S)[a]	$\bar{R}^2$	D-h /t[b]
[2]	[M not cause Q]	3.91 (3, 20)**	.96(2, 21)	.27	NC /0.91
[3]	[M not cause Q]	2.98 (4, 17)**	.52(3, 18)	.31	NC / 2

* Significant at 5 - percent level** Significant at 1- percent level

detrended time series value of Q.

Since the data for oil price includes three "shocks"--1973, 1979 and 1983--we apply the Chow test to explore whether there is any structural changes in the coefficients. The results indicate that causality test are not sensitive to sample periods. For testing serial correlation, since the test equations include lags, "Durbin-h" is used. In any case where this test could not be computed due to T[var(.)]>1, where T is number of observations and var (.) is an estimate of squared variance of the coefficient of the first lagged endogenous variable, we applied an alternative test called "m-test". Based on reported "D-h" or "t-value" for m-test, in Tables (5.9), (5.10), and (5.11) there are no serial correlation problem in the unrestricted test equations.

Conclusion

Using the Direct-Granger causality test, we have shown, that there is a unidirectional causality relation from oil price to wheat import in strict and instantaneous sense in Iran. In other words, the "past and present" history of oil prices are useful information to improve the prediction of wheat imports. The past and current history of domestic production of wheat (with and without time trend) is useful to improve the prediction of wheat imports, but this is not the case when we just consider the past history of domestic wheat production. As Feige and Johannes suggested causality tests may make important contributions to our understanding of fundamental economic relationship if used with caution. Checking the robustness of the conclusions under different testing methods is desirable. This can be done by using Vector Autoregression (VAR), which can investigate the effects of any "shock", thereby showing some causal characteristics.

Endnotes

1. Nominal Protection Coefficient is defined as the ratio of the domestic price divided by the international price, evaluated at the official exchange rate.

2. Prediction variance. Given a two variables regression model, $Y_t = \alpha + \beta X_t + \epsilon_t$ $t = 1, 2 \ldots\ldots, T$ and $\epsilon_t \sim N(0, \sigma^2)$. If assume α and β are konwn, the appropriate forecast for Y_{T+1} is given by $\underline{Y}_{T+1} = E(Y_{T+1}) = \alpha + \beta X_{T+1}$, the prediction (forecast) error is $\underline{e}_{T+1} = \underline{Y}_{T+1} - Y_{T+1}$. This prediction error has two desirable properties: (a) $E(\underline{e}_{T+1}) = E(\underline{Y}_{T+1} - Y_{T+1}) = (-\epsilon_{T+1}) = 0$ and (b) the prediction error variance is the minimum variance among all possible forecasts based on linear equations (see Pindyck and Rubinfeld, 1991).

3. The time series Q, is a trend-stationary process (TSP) (not a difference-stationar rocess(DSP). A TSP can be represented as $Y = \alpha + \beta t + \epsilon_t$. Deterending involves subtracting a (linear) trend ($Y - \beta t = \alpha + \epsilon_t$), in order to obtain a stationary process (LIoyd and Rayner, 1993).

CHAPTER VI. SUMMARY AND CONCLUSION

The geo-political economy of Middle East and North Africa (MENA) countries is dominated by three factors: little rain, much oil and rapidly growing population. Over the last forty years there has been significant changes in the farming sector throughout the region. Many rural societies have transformed the traditional subsistence agriculture with adoption of modern production techniques. Urban societies, on the other hand, have evolving consumption patterns. Characteristic of most countries in the region, oil export earnings is a major contributing factor driving these changes. This transition has occurred at different time and on different rate, but the significant changes occurred after the first oil shock in 1973/4.

The food security (supply food for all people in all time) situation at the national level in the oil exporting countries provide a classical example of interaction of a sector (i.e., agricultural) and the macro economy. The two favorable oil price shocks in the early and late 1970s, resulted to significant increase in per capita income. The high per capita income together with fast population growth created a food production-consumption gap. This was compounded by natural and socio-economic constraints (such as government price policy), particular in these countries, which limited domestic food production. It is in this context that food imports have been used as an important instrument to stabilize food availability for national security objectives in general, and for food security, in particular. During the last 20 years, food imports have become critical to food security program of MENA countries. Despite nearly all countries implementing import-substituting agricultural policies (i.e., self-sufficiency in food) except for Turkey, Morroco, and Iran, the region still import half their food supply. Reliance on imported food exposes these countries to substantial risk should foreign exchange availability decline; especially during drought period. The "bread crisis" in North Africa (e.g., Tunisia) in the early 1980s is a an example of this risk exposure. Therefore, analysis of food security of oil exporting countries which focus only on internal factors such as domestic production is not sufficient, because of the link oil provides to the domestic maco-economy as well as external forces. Today, in most of the MENA countries, food security strategies are at the forefront of national development plans and variation of oil price plays a vital role in the implementation of these plans.

This dissertation examined the relative influence of oil price shocks, as an external factor, on some internal factors such as income, food production, food imports, and variation of food consumption. The later is used as an indicator of food insecurity. The study uses a linear non-structural model--vector autoregression (VAR)--of five variables impacting the food security of Algeria, Iran, and Saudi Arabia.

Although closely similar in economic base and many other considerations, the three countries took different paths in their policy initiatives relating to food security. Algeria followed an industrialization-first policy with very scant attention given to domestic agricultural production and high dependency on food imports. Iran is also dependent on imports but have given agricultural policy and financial support (e.g., in particular, its price policy). Saudi Arabia is the only country of the three that heavely invested on production infrastructure in the agriculture sector. These different policy initiative directions proved influential in impacting the interactions of the variables relevant in food security.

The use of a time series data is appropriate for examining food security issues since more important factors impacting food security such as structural change (e.g., transformation of the rural society and rural-urban migration), gestation period of infrastructure invesment, and policy regime shifts are likely to have longer and persistent lag effect that may escape detection in a cross-section data. Also, from a methodological consideration, it allows testing whether the set of variables chosen as relevant in food security can be empirically tested for their relationship. This is especially important since most of the series have been found to be integrated. That is, individually they wander away without any tendency to revert to a mean level. However, a cointegration test reveals that a single, long-run equilibrium relationship governs the co-movement of these set of variables. This suggests that the set of variables are causally related in the long-run.

The first question addressed was the presence or absence of any Granger-causality linkages between the variables mentioned above. A 5-variable VAR model was used to examine this question. Statistical tests indicated that one year lag was appropriate for the model with differenced data. The results indicated that in Algeria the oil price "Granger-caused" food consumption, while in Iran and Saudi Arabia such strong causality relationship are not statistically significant. Also, per capita income "Granger-caused" wheat production in Algeria while in Saudi Arabia wheat imports "Granger-caused" wheat production. In the case of Iran, there is a unidirectional causality from oil price to wheat imports both when only past information is used (strict sense) and when current information is also included (instantaneous sense). The implication of these different causal relations could help planners to better understand food security and help them establish priorities in their national food strategies.

To explore the relative importance of variation in oil price to other variables, a forecast error variance decomposition (FEVD) is employed. In the case of Algeria, in the short-run the percentage of unexpected variations in oil price, wheat production, and wheat imports account for 7, 30, and 18 percent of variation in wheat consumption. In longer periods, that is after 2 years, oil prices appear to play increasing role (37%) in explaining the variation in the wheat consumption. In Iran, in the short-run wheat imports predominate the "other" variables in explaining the variation in wheat consumption and its share is maintained over time. In Saudi Arabia the short-run wheat consumption is nearly exogenous, and even in the long-run, wheat production and oil prices have only a modest effect on variation of food consumption.

This study also empirically examined the dynamic impact of one shock in oil price on the other variables in the system for each country. The impulse response function for Algeria shows that wheat imports and wheat consumption responses follow a similar pattern in the early period. The increase in oil price initially increases wheat consumption and then substantially declines after the second year. In Iran the impact of oil shock on wheat consumption is large in the short-run and disappear after 3 years. In Saudi Arabia responses to oil price shock shows that wheat production response is more sustainable and wheat consumption increases. This is consistent with Saudi Arabia historical data.

The longer, larger, and more persistent lag responses shown both in the forecast error variance decomposition and impulse response function clearly indicates that a single measure of covariability such as the coefficient of variation hides the "secondary variability" included as the system adjust back to an equilibrium position after the initial shock. These seconderary variability (which are more endogeneous in nature) may present to be more inmanageable in terms of stabilization policies than the more exogeneous initial shock.

The results of this study uncover the dominant sources of variation in food (e.g., wheat) availability (i.e., domestic production and imports) in Algeria, Iran and Saudi Arabia. This information will be very useful in planning food security policy initiatives that will reduce the variation in food availability and affordability.

The main sources of variation of food availability in Algeria for both the short-run and long-run are variation in per capita income and domestic production. The results of causality test indicate that there is a unidirectional causality relationship from per capita income to domestic production. In addition, when there is an unexpected change in oil prices, per capita income in Algeria shows a large response with long-lived lag adjustment. A general policy implication of these results suggest that oil and gas export revenue stabilization strategies via diversification could favorably impact on food security condition in Algeria.

In Iran, the main sources of variation in availability of food in the short-run and long-run is the variation in food domestic production. It is also shown that there is a inverse relationship between oil prices and domestic production, at least in the short-run, and the response of food production to an oil price shock is large and persistent. These results suggest that food security objectives in Iran could be better achieved by focusing on the production system. In addition, converting the subsidy bias which favored consumers to provide adequate incentives to producers is desirable.

In Saudi Arabia the main sources of variation in food availability both in the short-run and long-run are variation in oil prices and per capita income. Variation in oil prices has a direct and long-lived effect on per capita income. As the largest oil producer among the OPEC countries, Saudi Arabia could help improve its food security condition by pursuing oil price stabilization policy.

The policy emphasis of Saudi Arabia on massive investment in production and distribution infrastructure (e.g., irrigation system) financed primarily by oil export revenue has improved the country's food security condition. The same initiatives are recommended for Iran and Algeria which are better endowed (relative to Saudi Arabia) with resources for agricultural production.

Empirical contribution

The empirical contribution of this study is in the application of appropriate time series methodology in investigating food security issues in oil exporting countries. Food security is primarily concerned with variability of food availability (domestic production+imports). The VAR methodology, on the other hand, is very powerful in examining the co-variability of variables in a simultaneous model with dynamic adjustment.

First, the non-stationary property of the data series is properly accounted for and accommodated in the analysis. It is common knowledge that this property, if ignored, can lead to spurious regression and inferences.

Second, whereas earlier studies used only a single point estimate of variability such as the coefficient of variation (cv), the VAR model allows the decomposition of variability of variables (innovation accounting in FEVD).

Moreover, the variability due to lag adjusment as the system moves toward equilibrium in response to initial shock is also captured in the impulse response. As a result, the variability of a variable is decomposed both in its sources of variability and its variability over time.

Thirdly, whereas earlier studies examined the influence of factors on food security in a single equation regression, thereby automatically imposing the direction of influence, the simultaneous system used here capture the rich feedback interactions of variables in the system.

Suggestion for further research

One problem with standard impulse analysis is that there is no unique way to obtain orthogonalized innovations (shocks). Our dynamic response function are conditional on the ordering in Choleski decomposition. We use oil price, per capita income, wheat production, wheat imports, wheat consumption order. More research need when this ordering is changed. A possible approach to this issue is to pursue the structural VAR (Bernanke, 1986) in orthogonalizing the shocks. Also, with possible more observations in the future, longer lag length can be used to fully capture the dynamic adjusment in the system.

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